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EDITOR: R. O. WHYTE

PRODUCTION OF HERBAGE AND FORAGE CROP SEED IN THE UNITED STATES OF AMERICA

By the Staff of the Division of Forage Crops and Diseases, Bureau of Plant Industry, U.S. Dept. of Agriculture.

SEED of some forage crop is produced in every one of the forty-eight states of the Union. In some cases, like alfalfa and red clover, the areas of production are wide; in other cases, like meadow fescue or carpet grass, the areas of production are extremely limited. In some cases very large quantities of seed are produced and in other cases the production is insignificant.

Seed production in the United States is, in all cases, carried on under conditions of the greatest economy in growing and harvesting. Specialized production is almost unknown in this country, although it is true that in certain crops, particularly alfalfa, Ladino white clover and to a lesser extent red clover, some seed is certified as to variety, and in the South lespedeza seed is often certified as to freedom from dodder. There is also a U. S. Verified Origin Service under which certificates are attached showing that the seed in question was grown in the state mentioned. Such a certificate does not guarantee the variety or the quality, but merely that the seed was produced in the state mentioned. This service is of importance in the case of alfalfa seed and to a lesser extent in the case of red clover seed. It is important for the grower to know whether alfalfa seed was grown in Arizona or Montana, irrespective of whether the variety in question is guaranteed.

Statistics are available covering the production of seed of the more important forage crops, but are either entirely wanting or very defective in the case of crops produced to a small extent or locally. Methods of growing and harvesting will be referred to under the various crops but it may be said that, in general, special methods are not used, harvesting being done in almost every case by machinery, varying from a plain mower to a combine.

Most of the seed as produced by the grower passes through the hands of jobbers to wholesalers and then to retailers. The seed as produced by the grower must in every case be recleaned and thus there is a considerable spread between the price to the grower and that charged by the wholesaler who finally distributes the cleaned seed to the retailer. In some cases this cleaning is done by co-operative associations of growers; in such cases the usual spread between what the grower receives and what the wholesaler charges is not great or disappears altogether.

The methods used in the production of red clover, alsike clover and sweet clover in the United States are similar to those used in Canada. Information upon this point will be found in a paper by L. E. Kirk and others upon these crops. (See Herb. Publ. Ser. Bull. 23, Production of seed of herbage and forage legumes, Sept. 1937.)

Production of forage crop seed in the United States will be outlined under (1) leguminous crops, (2) grasses, (3) miscellaneous crops.

LEGUMINOUS CROPS

Alfalfa — Medicago sp.

Details of alfalfa production and methods used have been included in another paper (Bull. 23). Statistics of production are given in a circular entitled "Seed Statistics" issued by the United States Department of Agriculture, Bureau of Agricultural Economics, March, 1936, and the data given below have been taken from that circular. The acreage harvested for seed and the yield per acre vary widely and consequently the total production varies a great deal from year to year. The total production for the United States between 1925-34 varied from 37,248,000 in 1932 to 72,918,000 lb. in 1930. The states with an average production during the period of upwards of 5,000,000 lb. are Kansas, Idaho and Utah. Those producing between 3 and 5,000,000 lb. are South Dakota, Nebraska, Montana, Arizona and California, those producing between 1,000,000 and 3,000,000 lb. are Ohio, Michigan, Wisconsin, Minnesota, North Dakota, Oklahoma, Wyoming and Colorado. The other states shown had an average annual production for the period of 527,000 to 851,000 lb. each. The causes of the variation in production cannot in all cases be indicated but factors that influence production of seed are price of hay, price of seed, extreme drought, extremely wet weather in the eastern states, Ohio to Minnesota, and an unusual invasion of some disease organism or insect pests. For example, in 1931 Michigan produced 2,700,000 lb., but in 1932 the production fell to 1,080,000 lb. The production in Utah, where the average production between 1925-34 was 8,372,000 lb., fell quite gradually but steadily from 26,496,000 in 1925 to 1,080,000 lb. in 1932, since which time there has been an upward tendency.

Average yields per acre from 1925-34 varied from 75 lb. per acre in south-eastern North Dakota to 345 lb. per acre in southern Arizona. Yields per acre in important producing states have also fluctuated from year to year. For example, in western and southern Utah the production in 1925 was 400 lb. per acre, in 1930 it was 85 lb. per acre.

The areas of production of the hardy varieties of alfalfa, namely, Grimm, Baltic, Cossack, Ladak and Hardigan, are confined largely to the northern states, such as Michigan, Wisconsin, Minnesota, the Dakotas, Montana and Idaho. The mid-hardy alfalfa seed is produced mainly in Kansas, Oklahoma and Utah whereas the non-hardy is produced in Arizona and California. No alfalfa seed is produced south of the Ohio River and east of Kansas and Oklahoma. (See article by H. M. Tysdal Bull 23.)

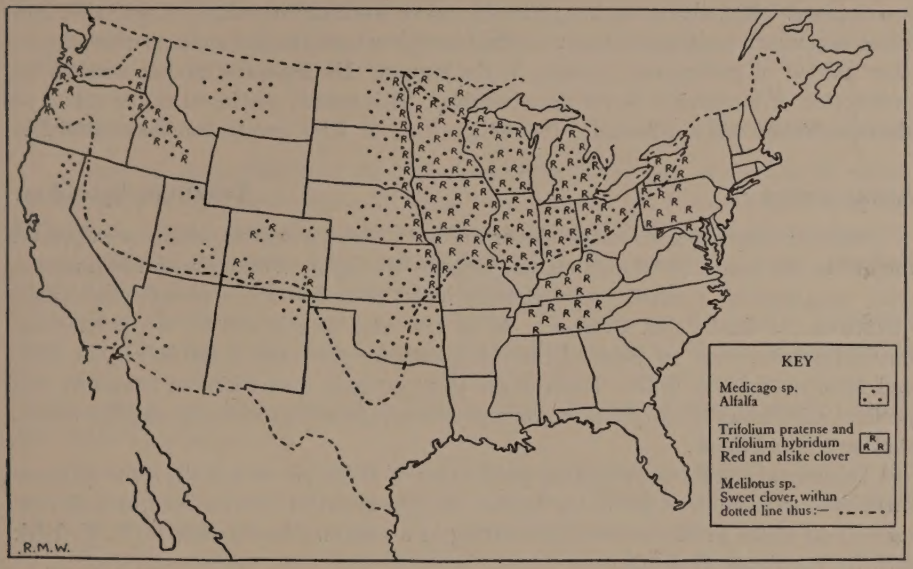

FIG. 1.—*Melilotus* sp. In Colorado, Wyoming, Utah, New Idaho and Montana, red clover, sweet clover and alfalfa seed are produced in mountain valleys or where irrigation is available. These areas are scattered, but the main centres have been shown. In Oregon the production in the east and centre is by irrigation, in the west without irrigation.

Red clover — Trifolium pratense

To-day production of red clover seed is confined to the area from New York on the east to North Dakota on the west and in the Inter-mountain and Pacific Coast states, particularly Idaho, Colorado and Oregon. Red clover seed was at one time produced in the New England states, although never to a very large extent. The production of red clover seed in the New England states has fallen in recent years. The states of largest seed production in 1938 were Indiana with 20,050,800 lb., Ohio, Illinois and Michigan with over 15,000,000 lb. each, Idaho with 6,270,000 lb., Iowa with 5,400,000 lb., and Oregon with 4,104,000 lb. The other states in this region had a smaller production or the statistics for red and alsike clover are combined so that it is not possible to tell how much of each was produced. The total production in 1937 was one of the smallest crops on record, aggregating 28,838,340 lb., a small part of which was alsike. In 1929, 122,638,000 and in 1932, 76,424,000 lb. were reported, in each case part being alsike clover seed.

The production of red clover seed in the various states has also varied widely. Ohio, which is usually the chief producer, produced 2,570,000 lb. in 1930 and 16,419,000 in 1938. These fluctuations again depend upon a number of factors, chief of which are wet weather at blooming time, the price of hay and the desirability of cutting the second crop for hay rather than for seed, extreme drought, low prices which incline farmers to cut the production of seed, or the advent of disease and

insect pests. Red clover seed is generally taken from the second crop, an exception being mammoth or single-cut clover which is taken from the first crop, usually after a short period of preliminary grazing in the spring. No separate statistics as to the production of mammoth clover are available. It is mainly produced in the states of the Ohio Valley and northward. (See article by L. E. Kirk and R. MacVicar, Bull 23.)

Alsike clover **Trifolium hybridum**

Separate statistics for alsike clover are not always available, but it is produced mainly in the states of Ohio, Indiana, Illinois, Michigan, Wisconsin and Minnesota, with occasionally a small production in New York and Pennsylvania and small quantities in Idaho and Oregon. As in the case of red clover, the production fluctuates from year to year. Ohio, for example, produced 2,160,000 lb. in 1926 and 10,635,000 lb. in 1927. The average yield per acre in the United States for the period 1925-34 was 175 lb. per acre, the highest average being in Oregon and Minnesota, the lowest in Illinois.

In general the factors affecting production of alsike clover are the same as those mentioned in red clover, but in the former the first growth is cut for seed, as with rare exceptions alsike produces only one cutting in a season. (See article by L. E. Kirk and R. MacVicar, Bull. 23.)

Sweet clover **Melilotus sp.**

Large quantities of sweet clover seed are produced, the total average annual production for the years 1925-34 being 55,573,000 lb. This fell to 33,528,000 lb. in 1935, the decline being rather gradual from the peak year of 1927, when 73,428,000 lb. were produced. In addition to the figures appearing in the statistics large quantities are usually saved by farmers for their own use. The outstanding states in production in 1935 were Minnesota with 11,520,000 lb. and North Dakota with 8,100,000 lb., but seed is produced in nearly every state from Ohio to Texas and north to the Canadian border.

There are no figures that enable us to make an accurate division between the quantities of *Melilotus alba* and *M. officinalis* produced, but by far the larger part of the seed is that of *M. alba*. *M. officinalis* is produced mostly in the northern states, such as Wisconsin and Minnesota, and at high elevations in mountain valleys. The agronomical methods used are described in another paper. (A. J. Pieters in Bull. 23.). Reference may be made here to the fact that there is always a considerable loss of seed from shattering during harvest. Various types of harvesting machines have been used, reaper, binder, combine and in some sections beating machines. The object is always to collect the seed with as little handling as possible because every additional operation results in loss of seed.

The Hubam or annual white (*M. alba annua*) is produced in the middle west, but the quantities are not large. Seed yields of Hubam are about the same as for the biennial white but harvest is late in October of the seeding year.

The annual yellow (*M. indica*) is not usually grown for seed, but the seed is a by-product of wheat harvest in southern California and Arizona. (See article by L. E. Kirk and T. M. Stevenson, Bull. 23.).

White clover **Trifolium repens**

There are three centers of production of white clover seed in the United States. In the order of quantities produced, these are Louisiana, the Idaho-Oregon area, and Wisconsin. Approximately one to one and one-half million lb. are produced annually, representing about one-half the annual demand in this country. Nearly one-half of the United States crop is harvested in Louisiana.

The methods employed are quite simple. In Louisiana the seed is harvested from permanent pastures, which are grazed from January to March, at which time the cattle are removed and the seed crop cut in May. After four or five years the yields become low, and thorough disking or light, shallow plowing partially restores the fields to productivity.

The crop is cut with a mower, allowed to lie in the swath until crisp but not dry enough to shatter, raked and cured in the windrow. When possible it is taken from windrow to thresher the same day. It is then cleaned and bagged.

Yields in Louisiana vary from 100 to 200 lb. per acre. Ripening is fairly uniform and only a small proportion is lost in handling. In the Pacific North-west, white clover seed is produced with and without irrigation, the latter in the area west of the Cascade Mountains, the former in Idaho and eastern Oregon. The crop is cut with a mower and raked. On irrigated fields in Idaho there are often two crops of bloom before cutting. Both crops are cut at the same time. Since many heads of the first crop have been wetted by the irrigation water, the result is a certain proportion of brown seed. Yields vary and may run up to 450 lb. per acre. Yields of 150 lb. are considered profitable. A short cutter bar is commonly used and the seed raked into windrows or bunches. The heads break off more readily in the dry climate of Idaho than in Louisiana.

In Wisconsin white clover seed is produced in an area extending to about 40 miles west and 50 miles north of Milwaukee. The plant volunteers in grain fields and seed may be taken the same season as the grain harvest ; alternatively, the field may be turned to pasture, in which case no seed is taken until the second year.

Production is seasonal and less has been harvested in recent years than formerly.

A mower is used for harvesting, and often a pan is attached to the mower and the material raked out of this pan in bunches, in which shape the clover is allowed to cure.

Ladino or giant white clover seed is produced under irrigation in Idaho, Oregon and northern California. Harvest is in September, the field having been grazed until the middle of June. The field is cut when heads are ripe as there is little shattering. The cut material is gathered into swaths and usually threshed from the field. Yields are low, about 60 lb. per acre being considered good.

Grasshoppers and rabbits are sometimes serious pests and for these poison bait and fencing are used.

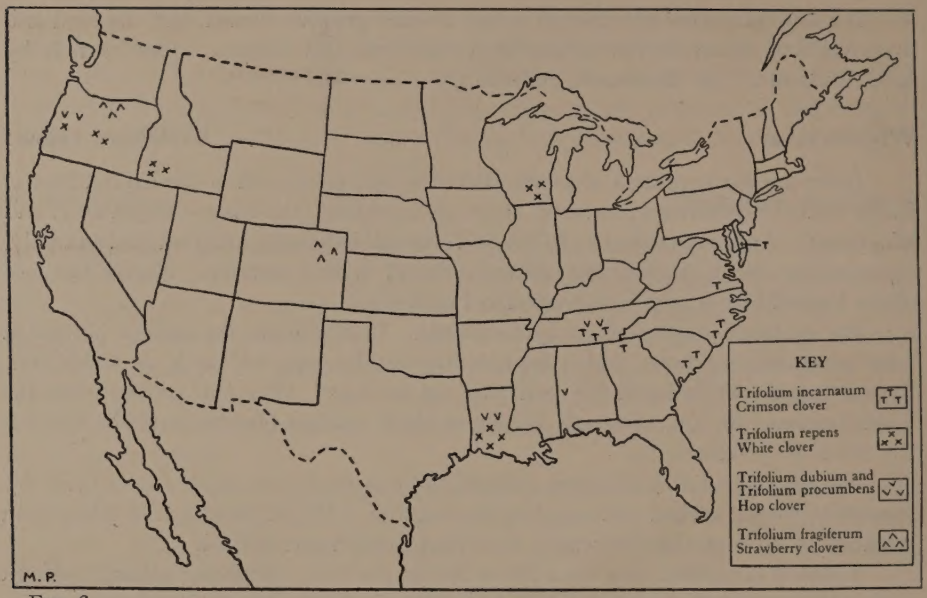

FIG. 2.

Crimson clover — Trifolium incarnatum

The production of crimson clover seed in the United States is largely confined to a section in south central Tennessee with small but varying production in Delaware and Georgia. Small amounts are produced in the southern Atlantic Coast and Gulf states but almost wholly for local consumption. The amount produced in Tennessee is probably greater than that produced altogether in other sections of the United States. Limited quantities are produced in south-eastern Delaware and small amounts are occasionally produced in Oregon. Here again the production fluctuates, although statistics over a term of years are not available. Reports of seed by the Bureau of Agricultural Economics in May, 1936, show that the production that year would be one-fourth to one-third smaller than in the previous year. Again the factors operative to some extent are the price of seed obtained by the grower, invasion of pests, and drought.

The methods employed in the commercial producing section of Tennessee (Franklin County) are as follows : To determine the proper time to cut, the grower examines the lower pods ; if these come off readily the field is at once cut. A mower or a reaper is used and the cut material left to cure in small bundles. In two or three days of good weather it is ready to thresh. The bundles are picked up with a broad barley fork and placed in wagon beds on which a canvas has been laid to catch seed that shatters in the handling.

In other states where the seed is grown for home use, it is stripped with a small-toothed hand stripper or a horse-drawn comb stripper. The seed is cured and seeded in the hull without being threshed. A few farmers have built suction machines by which the pods are sucked from the head.

Strawberry clover **Trifolium fragiferum**

Small amounts of this seed are produced in Oregon, Washington, Idaho and Colorado where the crop is proving unusually well suited to saline soils. The seed is taken from the regular pastures. When seed is wanted, the fields are not grazed until after harvest in August or there may be some grazing in early spring, the stock being removed early in May. The crop is cut with a mower, cured and threshed.

Hop clovers **Trifolium dubium, T. procumbens**

Seed of *Trifolium dubium* and of *T. procumbens* is produced in the United States, the former in Oregon, where it is not grown specially for seed, but is a by-product of the cleaning of red and alsike clover seed, the crop occurring as a volunteer in most of such fields in the producing area. There is usually also some seed of *T. procumbens*, but the seed is not separated from that of *T. dubium*. The total crop in Oregon has been estimated at about 6,000 lb.

The seed of *T. procumbens* is harvested only in central Tennessee, where about 1,000 lb. are produced annually. The pastures are mown with an ordinary mower when the heads are brown in late May and early June. The cut material is cured in windrows and cures in 1 to 3 days when it is threshed immediately. About 50 to 100 lb. of seed are secured but it is possible that more could be gathered by going over the fields with a suction machine. In threshing, care must be taken not to blow the seed over with the straw.

Persian clover **Trifolium resupinatum**

Small amounts of this seed are harvested in Louisiana where the plant has become naturalized. It makes permanent meadows by voluntary re-seeding.

For seed, cattle are removed in April and the seed is harvested in May, at which time the heads turn gray. Ripening is quite uniform, but the heads break off readily. Methods of cutting, curing and threshing are similar to those used in harvesting white clover seed in Louisiana. Yields vary from 200 to 300 lb. per acre. One seed crop per annum can be taken for an indefinite number of years. Some success has been obtained with harvesting by a suction machine.

Black medic **Medicago lupulina**

Black medic is harvested only in parts of western Alabama and there it is rather a by-product, occurring on the heavy limestone soils of this section together with Johnson grass (*Sorghum halepense*). Seed is ripe in the latter part of May or early June, before the Johnson grass seed. Two methods are then followed: a canvas sheet is laid under the baler when the Johnson grass hay is baled; by beating the hay as it goes into the baler considerable black medic seed is caught on the sheet; from 100 to 300 lb. per acre is the estimated yield by this method. If larger quantities of black medic are required, the hay is passed through a threshing machine and from 500 to 1,000 lb. of seed may be secured.

The fields are in continuous Johnson grass and black medic stands, being plowed and seeded to winter oats every two or three years to renew the vigour of the Johnson grass.

Bur clover **Medicago hispida, M. arabica**

Two species of bur clover are grown in the United States, namely : *Medicago hispida* and *M. arabica*. The former is most common in the Pacific Coast states and the latter in the southeastern states. Most of the bur clover of the western United States occurs spontaneously and it is as a waste from harvested grain that most of the seed is secured. Occasionally in this region, seed is harvested from range land where it occurs in abundance. In this case harvesting by hand sweeping and raking is usual. Harvesting by suction machines has been practised, but is not common. In the southeastern United States the spotted bur clover is harvested by allowing the seed to become thoroughly ripe and the burs to drop from the plant, after which the plants are mowed and removed with a horse rake, leaving the burs on the ground. These are then swept into windrows with rotary power sweepers or are brought together with hand brooms and rakes. The trash and heavy material are then cleaned from the burs as best possible and the seed offered to the trade in this condition, without hulling. In the southeastern United States, where summer rains occur, special handling of the windrowed or bunched burs when they become wet in the field is necessary. In the western United States this difficulty is not encountered. There are no statistics regarding the amount of bur clover seed harvested or handled by the trade. The amount is not large, since seedings usually are kept more or less permanent by volunteering. The acreage of spontaneous bur-clover in the United States is quite large, particularly in the western States.

Field pea **Pisum sp.**

There are no statistics giving the acreage of field peas harvested for seed in the United States. They are grown in widely separated regions for forage and cover crop use, but seed production is confined to the northern United States, principally in Oregon and Idaho. Some seed is produced in the Great Lakes states, but this is of less importance. In these regions large amounts of garden pea seed are produced, but not included here, although sometimes referred to as field peas. It is estimated that in 1938 about 40,000 acres were planted to field peas for seed production with an estimated seed yield of 25,000,000 lb. The crop is harvested in July and August, depending on seasonal conditions, locality, variety, etc.

Field peas are cut for seed when the pods are mature and the seed firm. If allowed to become too ripe, loss from shattering and weevil damage is sure to be large. They are most commonly cut for seed with an ordinary mower equipped with a bunching attachment, but a windrow attachment is used also with good results. When a bunching attachment is used, the bunches are moved out of the path of the horses on succeeding rounds. This method leaves the peas in better condition than

when they are windrowed and to a large degree prevents the shattering which would accompany the use of a hay rake.

Threshing is usually done with an ordinary grain separator properly adjusted. Considerable threshing of field peas in recent years, however, has been done by combines, the field peas being handled in a similar manner to the small grains or picked up from windrows or swaths with pick-up attachments.

Crotalaria — *Crotalaria sp.*

Seed of crotalaria can be produced throughout the coastal plain and lower Piedmont region of the southeastern United States ; however, commercial production is confined largely to the states of South Carolina, Georgia and Florida. Three species are grown, namely, *C. spectabilis*, *C. striata*, and *C. intermedia*. The seeding habits of these are very much alike, although *C. striata* ripens seed over a much longer period than the other two species. The usual harvesting period is from the end of September through October. All three species are harvested by hand, the seed in the pod being stripped into bags or similar containers and piled under some sort of shelter, or sometimes in the open, to dry. The depth at which they can be piled depends on the ripeness or dryness of the pods. Heating from moisture must be avoided. When the pods are thoroughly dry they are run through a special crotalaria huller or through a specially adjusted clover huller or thresher. Any machine with a cylinder, concave, and with sufficient teeth will thresh crotalaria satisfactorily.

In experimental trials *C. spectabilis* which had been allowed to become thoroughly ripe and dry has been threshed with a combine thresher, but this method has not been regarded as practical.

Yields have varied from 200 to nearly 1,000 lb. per acre. No statistics are available for total production, but it is estimated that about 2,000,000 lb. are produced annually.

Annual beggar weed — *Desmodium purpureum*

There is a small but regular seed production of this plant in northern Florida and southern Georgia. The seed matures in late summer and is stripped from the plant by hand. The stripped seed is allowed to lie in piles to cure and is later hulled. The commercial seed is always hulled.

Cowpeas — *Vigna sinensis*

The cowpea is the best known and is one of the most extensively grown leguminous crops in the southern states. It is cultivated mainly for forage and to improve the soil, but the seeds, chiefly of the Blackeye and White varieties, are rather commonly used for human food. In a very large proportion of the area planted to cowpeas, little effort is made to harvest the seed. The principal seed-producing states are South Carolina, Georgia, Alabama and Mississippi.

The principal factors in making the cowpea an undesirable crop to grow in a

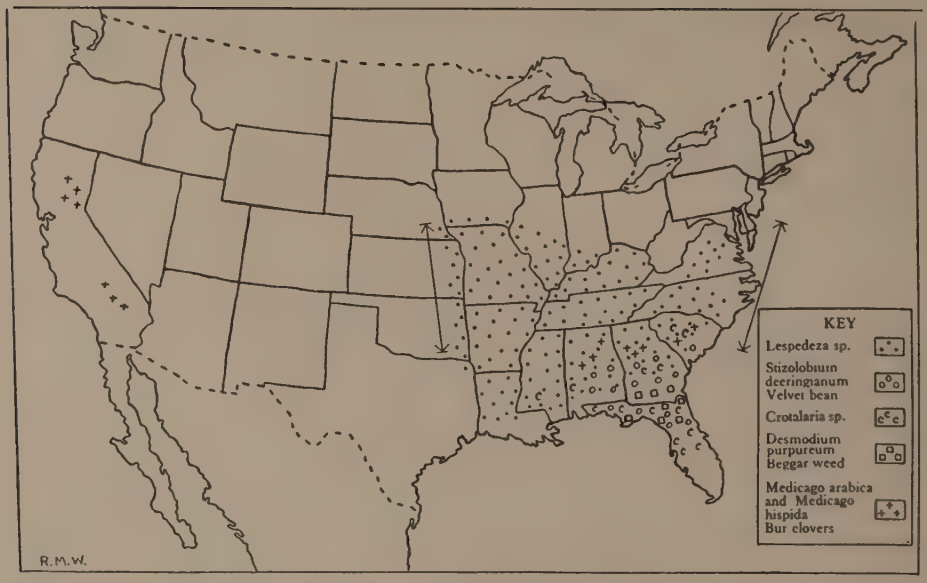

FIG. 3.—*Lespedeza* sp. In a belt included in ↕ mainly *L. stipulacea*. South of that mainly *L. striata*. *L. sericea* in scattered localities throughout the area.
Crotalaria sp. Mainly *C. striata* and *C. stipulacea*. An early variety of the latter in South Carolina.

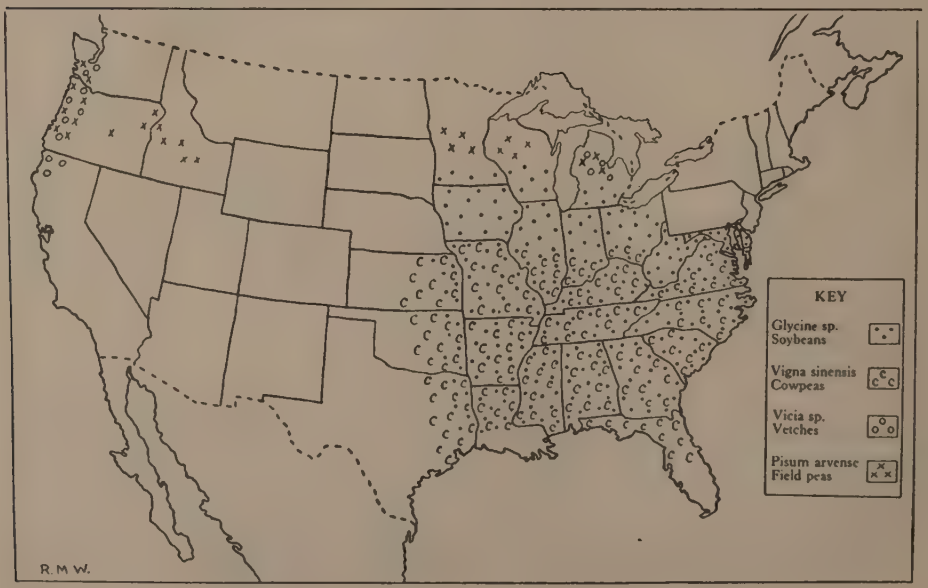

FIG. 4.—*Vicia* sp. In Oregon various species. In Michigan *V. villosa* only.

commercial way for seed production are the uncertainty of a seed crop, the expense of harvesting, and the low yields generally obtained. Various methods of harvesting the cowpea for seed are employed in different sections of the cowpea region. Hand picking is the most common way of saving the seed, although the most expensive and laborious, and is the only practical method when the crop is grown in corn. When large fields are grown for seed production, various machines are used for cutting the vines. In the Blackeye pea districts of California, a bean cutter, consisting of a pair of sharp knives about 3½ feet long and mounted on a sled from which they stand inward and slope backward at an angle of 60°, is the commonest implement for harvesting. The ordinary grain separator can be adjusted to thresh cowpeas successfully and is the machine most generally used. When the pods are hand picked, the seeds are beaten out with flails or the pods run through a pod huller.

Velvet beans **Stizolobium deeringianum**

Although velvet beans are especially adapted to the well drained portions of the Atlantic and Gulf Coastal Plain areas, the production of seed is confined largely to Alabama, Georgia and Florida. On account of the extensive tangled growth of the vines of velvet beans, it is necessary to pick the pods by hand. This is also true of the bunch or bush variety on which the pods are borne close to the ground. When velvet beans are to be fed to cattle or ground into meal it is not necessary to hull them. For this reason the quantity of beans threshed is generally limited to those which are to be used or sold for seeding purposes. The beans are usually threshed with a flail or with one of the several threshing machines designed for the purpose. Regardless of the method of threshing, only well matured and thoroughly dried pods can be threshed without difficulty.

Soybeans **Soja max**

See article by W. J. Morse in Bull. 23.

Vetches **Vicia spp.**

See article by R. McKee in Bull. 23.

Lespedeza **Lespedeza spp.**

See article by A. J. Pieters in Bull. 23.

GRASSES

Brome grass — Bromus sp.

There are no actual figures available on the seed production of this grass, but it has been estimated that about 500,000 lb. per annum are produced. In 1935 the seed production was roughly estimated at 1,000,000 lb., but in 1938 only 600,000 lb. were produced. North and South Dakota are the principal seed-producing states, with smaller quantities of seed harvested in Kansas, Minnesota, Montana and Nebraska. Canada produces a very large amount of brome grass seed. (See article by T. M. Stevenson and L. E. Kirk in Bull. 19.)

Brome grass usually produces the highest yield of seed in the second year after seeding. The average yields are from 250 to 300 lb. per acre, occasionally as high as 600 to 800 lb. The grass is cut when the seed is fully formed and nearly ripe, that is, in late June or July. The harvesting is done with an ordinary binder, field mower, stripper or header. After harvesting, the bundles or heads are allowed to dry before threshing with ordinary threshing machines. The seeds are quite large and light, making it necessary to thresh with care to guard against blowing the seed over with the straw or chaff.

Reed canary grass — Phalaris sp.

The original source of seed for this grass in the United States was the state of Oregon, where it has been grown as a cultivated crop in Coquille Valley in Coos County since about 1885. It is believed that most of the planting in the Pacific Northwest can be traced from this source. Now, however, seed is being harvested in addition to this location, in Wisconsin, Minnesota and Iowa. Canada has, for a long time, produced a quantity of this seed. It is impossible to obtain any estimate of the amount of seed produced in the United States.

Much of the seed is harvested by hand because of the irregular time of maturity and because it shatters very easily when mature. Some seed is harvested with headers, while the Wisconsin Agricultural Experiment Station, in co-operation with a grower, has constructed a seed harvester from an old grain binder. All unnecessary parts of the grain binder have been removed and a large hopper built on the platform with the sickle bar mounted in front of this hopper. The seed heads are carried back to this hopper by the reel. It has been reported that 1,500 lb. of seed have been harvested in five or six days with this machine. A similar machine has been built in Minnesota. The seed heads are allowed to cure or dry, either on racks outside the buildings, if the weather is suitable for drying, or under sheds, or in buildings. Some seed is dried on floors, but this method takes longer for curing. Yields of clean seed varied from 30 to 150 lb. per acre.

Carpet grass — Axonopus compressus

This grass is found growing over most of the Coastal Plain States and is particularly well adapted to the sandy soils. Alabama, Mississippi and Louisiana are the principal seed producing states, although some seed is produced in other states

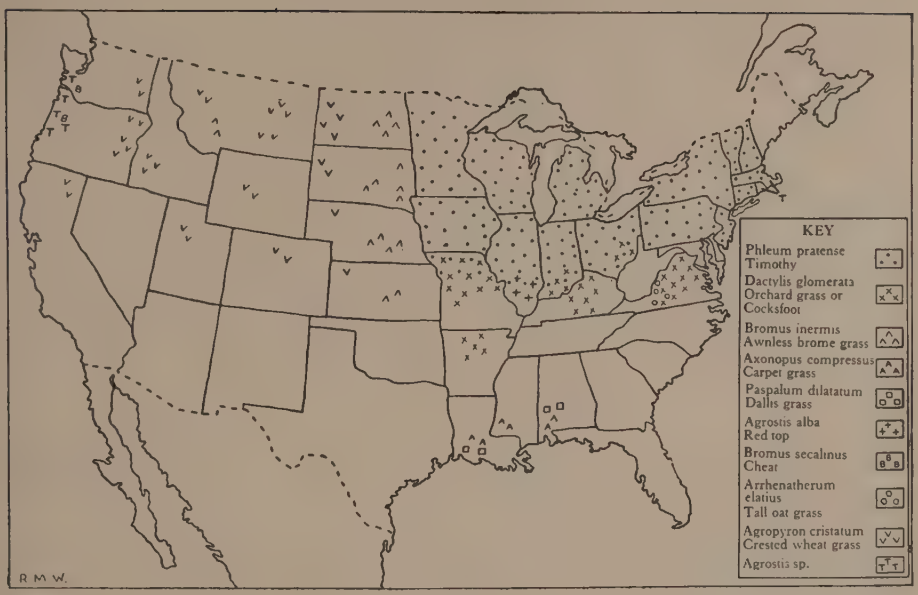
KEY
Phleum pratense
Timothy
Dactylis glomerata
Orchard grass or
Cocksfoot
Bromus inermis
Awnless brome grass
Axonopus compressus
Carpet grass
Paspalum dilatatum
Dallis grass
Agrostis alba
Red top
Bromus secalinus
Cheat
Arrhenatherum
elatius
Tall oat grass
Agropyron cristatum
Crested wheat grass
Agrostis sp.
R M W.

FIG. 5.

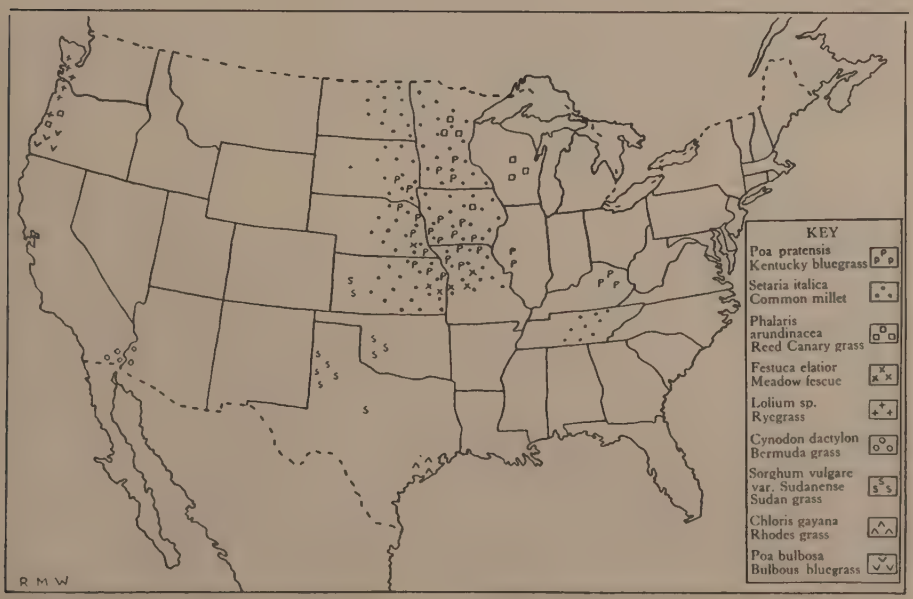
KEY
Poa pratensis
Kentucky bluegrass
Setaria italica
Common millet
Phalaris
arundinacea
Reed Canary grass
Festuca elatior
Meadow fescue
Lolium sp.
Ryegrass
Cynodon dactylon
Bermuda grass
Sorghum vulgare
var. Sudanense
Sudan grass
Chloris gayana
Rhodes grass
Poa bulbosa
Bulbous bluegrass
R M W

FIG. 6.

in this region. It has been roughly estimated that about 300,000 lb. of this seed were produced in the United States in 1938. It produces on the average from 50 to 100 lb. of seed per acre. The usual method of harvesting is to mow with a field mower at a time when the seed is fairly mature, but when the grass is somewhat damp, as the seed shatters quite readily. Field mowers equipped with clover bunchers are used to reduce shattering. After drying for about two days, it is threshed with an ordinary threshing machine, care being taken to use the proper screens and to reduce the blast of air to prevent the seed blowing over. It has been reported that 1/20 inch mesh sieves will let the seed through, while 1/38 inch mesh will retain them. A considerable quantity of this seed is threshed by beating out the straw with a flail and cleaning with a fanning mill. In recent years some seed has been harvested with a combine-harvester; when harvested in this manner, the seed is allowed to become fully mature, which usually occurs in September.

Bermuda grass **Cynodon dactylon**

This grass is found growing over the entire southern United States, but most of the seed is produced in California and Arizona. In general, it produces seed rather sparingly in the humid regions, as hot dry weather is best adapted for seed development. Approximately 50,000 lb. of seed were produced in the United States in 1938, an amount which was less than usual. Much of the seed harvested in Arizona and California is in a mixture with alfalfa which has been harvested for seed. After threshing the alfalfa seed, the Bermuda grass is removed by cleaning and fanning mills. The yield of seed varies from 100 to 200 lb. per acre. In Imperial County, California, and Yuma and Maricopa Counties in Arizona, one or two seed crops are harvested annually, in June and September, from stands that remain down for a number of years. The grass is harvested with an ordinary field mower and threshed as soon as possible.

Orchard grass **Dactylis glomerata**

This grass is grown over a considerable area in the United States, but most of the seed is produced in Kentucky, Virginia and Missouri, with smaller quantities in Arkansas, Indiana and Ohio. In Kentucky, the principal seed producing section is located in Henry, Shelby, Woodford, Oldham and adjacent counties. In this region it is the common practice to seed orchard grass in September at a lighter seeding rate when it is grown for seed production, while for pasture it is spring sown at a heavier rate. In other seed producing areas it is sown either in the autumn or spring. The stands usually remain down from three to eight years. The Bureau of Agricultural Economics reported a yield of 150,000 to 175,000 bushels of seed in 1934, and 135,000 bushels estimated in 1938. The yield varies from 7 to 16 bushels per acre. For seed harvest it is cut with a grain binder, tied in small bundles and then shocked and cured, a process which requires from two to four weeks. It is then threshed with an ordinary threshing machine. In Missouri, orchard grass is grown

in a mixture with red clover or Korean lespedeza. About the middle of June, when the orchard grass seed is mature, it is cut high and the seed crop stacked. It remains in the stack about five weeks before threshing. Some seed is being harvested with the combine-harvester. Hay is usually cut immediately after the seed has been harvested.

Sudan grass **Andropogon sorghum var. Sudanensis**

Texas, Kansas and Oklahoma are the principal seed producing states for commercial purposes, although some seed is harvested for local use in western Missouri, eastern Colorado and New Mexico. California and Arizona produce some seed under irrigation, but in general other crops are more profitable under those conditions. In general, for seed production, it is sown in rows varying from 18 to 36 inches in width, the higher yield being obtained when sown in rows of 18 to 24 inches, but when grown under irrigation higher yields of seed are obtained when sown broadcast, or in close drill rows. It is harvested with a grain or row binder when almost mature and bound like grain. It is then allowed to cure in the shock, although sometimes it is stacked. If the grain is rather green when stacked there is a danger of heating, which injures the vitality of this seed. If covers are used on the shock, a brighter seed is obtained. After curing it is threshed with the ordinary grain thresher. Sometimes a clover huller is used. When the latter machine is used, more of the hull is removed and a heavier seed is obtained. The crop may be allowed to mature and is then harvested with a combine-harvester.

Seed yields vary in different regions. In Lubbock, Crosby, Floyd, Hale and Swisher Counties in Texas, yields of 600 lb. per acre are obtained, while in other dry-land regions the average is about 270 lb. per acre. The yield under irrigation is 900 to 1,000 lb. per acre. Where Sudan grass is grown for seed, care must be observed if sorghum is also grown, as the Sudan grass will hybridize very readily.

Meadow foxtail **Alopecurus pratensis**

Small quantities only of seed are produced in Oregon and at high elevations in Idaho. No data are available as to quantities, but the supply is not equal to the demand.

In Oregon the seed is stripped by hand as it matures very unevenly. In Idaho a mower is commonly used, the crop being handled like a hay crop and threshed.

Cheat **Bromus secalinus**

A small amount of this seed is produced in the Willamette Valley of Oregon, where the hay is used for horse feed. The crop is seeded in the fall, grazed sometimes with sheep in winter and cut for seed early in July. The crop ripens quite uniformly and there is little shattering when cut with a mower or binder. Yields are said to vary from 600 to 1,000 lb. per acre or occasionally even more.

Rhodes Grass **Chloris gayana**

As far as is known this is gathered only on one ranch, the famous King Ranch in the Texas Gulf Coast area. The seed crop is taken from the regular pasture fields with either an ordinary grain binder or combine harvester. Ripening is quite uniform and after full maturity there is a tendency to shed. Sowing is done in late February and March and seed is harvested at various times from June to December depending on the number of hay crops cut before the seed crop is taken. Various machines have been successfully used for harvesting ; a bluegrass stripper, a wheat header, and a small combine have all given good results. Threshing is done as soon as possible after curing in the field and the yields vary from 300 to 500 lb. of clean seed per acre. While the plant is a perennial, it is necessary to allow some volunteering if the field is to be kept in productive condition. When this is done, one seed crop can be taken annually for from five to twenty years.

Ryegrass **Lolium sp.**

This is produced in Oregon and Washington west of the Cascade Mountains where the rainfall varies from 30 to 100 inches.

Here the annual form, known as western or domestic ryegrass, is grown for seed only as an annual crop. It is a mixture of annual and short-lived perennial types. It is grown in rotation with small grain, but seeded alone at the rate of 20 to 25 lb. per acre in the fall. Harvest is in July when the plant has turned brown. Care must be exercised in harvesting, as the ripe seed shatters readily. Consequently the field is cut when about 75 per cent mature. Mowers, binders, or headers are used for cutting and the material left only long enough to cure, after which it is threshed, usually in late July or early August. Threshing is done with the stationary grain thresher or combine equipped with pick-up attachment.

The English ryegrass is mostly taken from seedings made primarily for seed production purposes, but occasionally during favourable seasons such seedings are used for pasture. The methods used in harvesting are as described above.

Meadow fescue **Festuca sp.**

Seed of this grass is produced almost wholly in eastern Kansas, western Missouri and eastern Nebraska. Production has declined in Missouri, but the total production for 1933, 1934 and 1935 has been estimated at 500,000, 500,000 and 900,000 lb. annually, with a decline since that time, and a small crop of only 125,000 lb. was produced in 1938. The fields are left for three to six years, being usually seeded without nurse crop at the rate of 10 to 18 lb. per acre, the rate varying in different sections. Seed is harvested in late June or in July, when the heads are brown or straw color, and is usually cut with a binder. A combine is sometimes used. Threshing usually follows immediately after curing. One crop of seed is taken annually and some grazing is furnished after harvest.

Bulbous bluegrass **Poa bulbosa**

This crop, which is harvested in Oregon, mainly in Jackson and Lane Counties, and to a lesser extent in Siskiyou County, California, is not a true seed crop, but consists of bulblets formed in place of seed and used as seed for purposes of planting.

The grass is grown either alone or with alfalfa. In either case it is cut with a mower. When alone, a swather is used and the material cocked when dry or left in the swath until threshed. When growing with alfalfa it remains in the swath until about half cured, after which it is windrowed. It may later be cocked or threshed from the windrow.

When cured it is threshed with ordinary grain threshers in which the toothed concaves have been replaced with blanks.

The yields vary from 500 to 1,000 lb. per acre.

Tall oatgrass **Arrhenatherum elatius**

As far as is known, this is grown only in a section of northern Virginia ; the use of the crop is declining, as orchard grass seems preferable. It is grown in rotation with small grain and corn, 15 to 20 lb. of seed being seeded on grain in early spring. When a seed crop is required, grazing is delayed until after harvest, which occurs in mid-June. The crop is cut with a mower or a binder and placed in small shocks until threshed ; yields of 150 to 200 lb. clean seed per acre may be expected. Fields are left for 2 to 5 years.

Dallis grass **Paspalum dilatatum**

The seed of Dallis grass is harvested only to a very limited extent in the United States, namely, in a small area in South Central Louisiana and West Central Alabama. There is no special culture, the seed being taken from established pastures which may be nearly pure Dallis grass or a mixture of Dallis and other grasses or legumes.

The seed stalks are formed in June ; if this crop is cut, a new crop of stalks will appear, making it possible to harvest 2 or 3 seed crops in one season. The quantity produced at any one time is small, the seed stalks being scattered and not in a dense stand. About 50 to 60 lb. of seed per acre are secured at a cutting.

The seed may be cut while the field is grazed or the cattle may be turned out of the field temporarily. The grass is cut with a mower and windrowed After curing, the seed is threshed at once ; if this is not possible the material is placed in large stacks to prevent rain damage. The threshed seed is spread out to cure, as it is important to prevent heating, which may seriously affect the germinability of the seed. The production of viable seed is materially reduced by ergot.

Red top **Agrostis sp.**

About 95% of all the red top seed in the United States is produced in a limited area in southeastern Illinois, chiefly in Marion, Wayne, Clay, Richland and Edwards

Counties. The soils here are gray, sour, and underlaid with an impervious non-calcareous subsoil. During 1922-33, seed was harvested from an average area of 204,800 acres. Yields vary from 30 to 75 lb. per acre and during this period the annual production was 11,120,000 lb. of clean seed.

Seed is taken from hay or pasture fields, the latter being usually grazed for about 15 days in spring. The plants bloom in late June or early July and seed is harvested soon after blooming is completed. Maturity is indicated by a yellowing of the panicles and a silvery cast to the seed, but is not uniform, extending over a period of about 2 weeks. Care must be taken to avoid shattering, which is serious when plants are fully mature.

Harvesting is done with mower or binder; the seed is threshed from the field about 2 weeks after harvest, or is stacked and threshed later according to convenience.

The Millets

There are at least three kinds of types of millet grown on rather extensive acreages in the United States. These are: Foxtail millet (*Setaria italica*), Proso or Broomcorn millet (*Panicum miliaceum*) and Japanese or Barnyard millet (*Echinochloa crus-galli* var. *edulis*). Information regarding seed production will be confined to these three kinds, because Pearl millet (*Pennisetum glaucum*) is grown only on very limited acreages in the southern states and is rarely, if ever, included in statistics on millet. Information on millet seed production is taken from a circular entitled "Seed Statistics," issued March, 1936, by the Bureau of Agricultural Economics, United States Department of Agriculture. The leading states in order of importance in millet seed production in 1919 were Colorado, South Dakota, Tennessee, New York, Iowa and Kansas. This represents a considerable shift from the situation in 1909 when the six ranking states were, in order of importance, Kansas, Nebraska, Iowa, Tennessee, South Dakota and Missouri. In 1919, North Dakota, which does not appear in either of the preceding lists, ranked third in millet seed production and Minnesota was sixth. It is apparent, therefore, that the West North Central group of states produces most of our millet seed.

No division of domestic seed production by classes is possible. In general, however, the foxtail millet comes from nearly all the producing states. Proso seed is produced chiefly in the Dakotas and Colorado, while Japanese millet probably makes up a large percentage of the total from New York. Yields vary according to the variety, cultural conditions and rainfall, the average being about 15 to 25 bushels per acre. The accepted weight per bushel in most states is 50 lb. and the quality of millet seed is generally high both in purity and in germination.

Little need be said as to the methods of growing, harvesting and threshing millet, since all these processes differ little from those used in producing wheat or oats. Millet is generally seeded with a grain drill or broadcast on a seedbed prepared by plowing and harrowing. It is usually harvested with a grain binder and threshed with an ordinary threshing machine such as is used in threshing small grains. The

season required for maturity is short, about 90 days or less, and this allows for seeding almost at any time from May 1 to July 15. It should not be seeded, however, until the soil becomes warm.

Kentucky bluegrass **Poa pratensis**

See article by A. J. Pieters in Bull. 19.

Bent grass **Agrostis sp.**

See article by H. A. Schoth and F. A. North in Bull. 19.

Timothy **Phleum pratense**

See article by Morgan W. Evans in Bull. 19.

Crested wheatgrass **Agropyron cristatum**

See article by Leroy Moomaw in Bull. 19.

MISCELLANEOUS CROPS

Alfilaria **Erodium cicutarium**

This species of *Erodium* is of economic importance only in the southwestern part of the United States. In California and Arizona in particular, it occurs spontaneously and is of importance on range lands where it often makes up a high percentage of the pasturage. Seed is harvested from the more favourable range locations where alfilaria often occurs in almost pure stands. It is never planted for seed production. Usually the seed is allowed to become thoroughly ripened and shattered from the plant. It is then raked and swept into piles and further handled entirely by hand.

Occasionally the crop is mowed before thoroughly ripened and raked together in bunches where it is allowed to dry thoroughly and shatter. It is then handled by hand, no set method being followed for further cleaning.

PRODUCTION AND GEOGRAPHIC DISTRIBUTION OF FORAGE CROP SEED IN CANADA

L. E. Kirk and R. M. MacVicar

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Forage crop seeds are grown more or less in every province of the Dominion in accordance with agricultural requirements and soil and climatic adaptation. Ontario is by far the largest producer of alfalfa, red clover and alsike, but considerable amounts of alfalfa seed are produced also in Manitoba, Saskatchewan and Alberta. Manitoba heads the list for sweet clover, followed by Ontario and Saskatchewan. Quebec is noted for its large production of timothy seed. The production of brome, slender wheat and crested wheat grasses is confined to the three western wheat producing provinces, Manitoba, Saskatchewan and Alberta. Canadian bluegrass seed is grown only in Ontario, and the bent grass seeds only in Prince Edward Island and New Brunswick of the Maritime provinces. Spring vetch seed is grown on a small scale in Quebec, and millet seed in Ontario.

As the agricultural area of Canada is subject to an exceptionally rigorous winter climate, only hardy strains of grasses and legumes are grown. This means that any export surplus of seed may be regarded as dependable in winter hardiness, and as suitable for use in northern as well as temperate countries throughout the world.

Production of the different seeds varies year by year, due to caprices of the climate. Sometimes in eastern Canada, heaving of the plants by frost occurs in the spring season just after the snow has thawed, or prolonged drought is experienced, as in south-western Ontario in 1936, or an intensive heat spell or wet weather at the time of blossoming may reduce the yield. These factors take their toll in reduced crop. The production of red clover seed, for example, may range from 1,000,000 to 4,000,000 lb. per annum.

Most of these forage crop seeds are marketed by growers to wholesale seed houses. The latter clean the seed to grade and distribute it to the domestic retail trade and export any surplus. Some seed is sold also by growers direct to other farmers and there are a few seed growers, co-operative associations which dispose of the seed grown by their members, but the greatest volume of seed is handled by the wholesale seed houses.

The high standards of quality demanded by the Canadian Seeds Act have been an important factor in promoting the production of clover and grass seeds of high quality, in point of viability and freedom from weed seeds and other impurities. An increasing quantity of seed is being grown under the certification and registration systems of the Dominion Department of Agriculture.

Certification is a service performed by the Dominion Seed Branch which in-

volves inspection of the growing crop, later inspection of the threshed seed, and sealing of the seed in the sack. Seed may be certified as to variety, freedom from particular impurities or any other characteristic of special economic significance.

Varieties approved by the Canadian Seed Growers' Association are eligible for registration. Registration combines all the advantages of certification with a guarantee as to purity of breeding. The latter is insured by a system of recording the pedigree of each generation of seed stocks and by regulations in regard to adequate isolation of the growing crop and approved methods of handling the seed in order to prevent mechanical mixtures.

The accompanying sketch maps of eastern and western Canada show the various sections of the Dominion where seed of the different grasses and legumes are produced. It is the intention in the following paragraphs to present a brief survey of the seed growing areas with respect to each species, together with a few statistics as to the average annual production and variations which occur from year to year.

ALFALFA (*Medicago media*): With respect to alfalfa seed production, both eastern and western Canada have been self-supporting for many years. Ontario Variegated, the chief variety grown in eastern Canada, is produced almost wholly in Ontario, and mainly in the south-central part of the province. In western Canada the Grimm variety takes precedence over all others. Until a few years ago seed of the Grimm variety was produced mainly on irrigated land in the Brooks area of southern Alberta. At the present time substantial amounts of Grimm alfalfa seed are produced also

Map showing the areas in eastern Canada where alsike, alfalfa, and sweet clover seeds are produced.

in the inter-lake region of Manitoba. In Saskatchewan, the White Fox district in the northern part of the province produces 500,000 lb. and promises to become an important source of Grimm alfalfa seed in the near future. These are the four main seed growing districts in Canada, but some seed is produced also in the Ottawa valley of Ontario, the central part of Saskatchewan and in certain valleys of British Columbia.

The total average annual production of alfalfa seed in the past few years has approximated 2,500,000 lb. About three-quarters of the alfalfa seed is produced in Ontario. The annual production has ranged from 1,000,000 to 4,000,000 lb. according to seasonal conditions.

Red Clover (*Trifolium pratense*) : Over 85 per cent of the red clover seed grown in Canada is produced in the province of Ontario. Nearly all of the balance is produced in British Columbia and Quebec. In Ontario, the main producing area is the south-western part of the province, but substantial quantities come also from the Ottawa valley and northern Ontario. All but a small amount of the red clover seed produced in Canada is of the early double-cut type.

The estimated normal annual consumption of red clover seed in Canada is 4,000,000 lb. as against an average annual production of 1,750,000 lb. The variability in total production from year to year, however, is considerable, ranging from 1,000,000 to 4,000,000 lb.

Map showing the areas in eastern Canada where red clover and timothy seeds are produced.

Alsike (*Trifolium medium*) : Ontario produces most of the alsike seed grown in Canada, the average production for the last five years being about 6,000,000 lb. Relatively small amounts of this seed are grown also in Quebec and British Columbia. The bulk of the seed grown in Ontario comes from the south-central section of the province, with substantial quantities from northern Ontario.

Sweet Clover (*Melilotus* spp.) : The amount of sweet clover seed used in recent years in Canada has been about 3,000,000 lb. annually. The average annual production of approximately 4,000,000 lb. is sufficient to satisfy domestic requirements with some surplus for export. Manitoba is the largest producer of this seed with an average annual yield of 2,000,000 lb. ; Ontario comes second with about 1,500,000 lb. Saskatchewan produces most of the balance, or about 500,000 lb. per year. The accompanying maps show the areas where sweet clover seed is grown.

Timothy (*Phleum pratense*) : The annual domestic consumption of timothy seed is about 10,000,000 lb. Production has exceeded this amount in at least one season when prices were high, but normally the annual production is about 5,000,000 lb.

The St. Lawrence Valley in Quebec, and eastern and western Ontario, are the chief sources of timothy seed. Substantial quantities are produced also in British Columbia and Alberta, and lesser amounts come from the Maritime provinces.

Brome Grass (*Bromus inermis*), Slender Wheat Grass (*Agropyron tenerum*), and Crested Wheat Grass (*Agropyron cristatum*) : Seed of these three grasses is produced in the three prairie provinces of western Canada, and in approximately the same soil-climatic zone (see accompanying map of western Canada). Seed production is more or less confined to certain localities scattered throughout the area indicated, each species being grown on the soil types and under the climatic conditions to which they are best adapted.

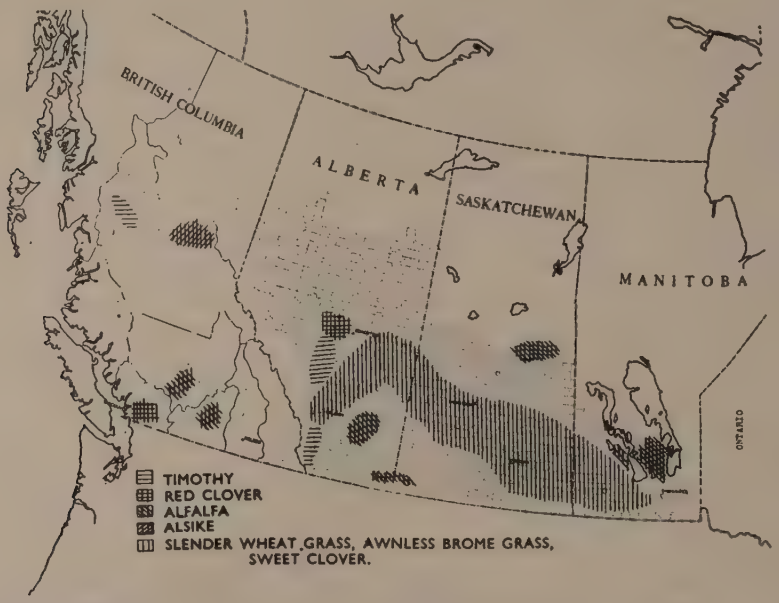
Saskatchewan is the largest producer of brome grass seed, with lesser quantities produced in Manitoba and Alberta. The average annual crop of this seed is a little over 1,500,000 lb. but the seasonal variation in yield ranges from 750,000 to over 3,000,000 lb.

Seed production of crested wheat grass, a comparatively new crop, is just starting. The 1935 production of crested wheat grass seed increased to 350,000 lb. from 60,000 in 1934, and it is estimated that in 1936 the total yield will be over 600,000 lb.

Less than 200,000 lb. per year of slender wheat grass seed is now being harvested. This species has lost popularity in recent years and is being replaced by brome and crested wheat.

Canada Bluegrass (*Poa compressa*) : Seed of this species is produced on heavy clay soil in a comparatively small area of south-western Ontario. The seed is obtained for the most part as a by-product from the grain crop. Production varies according to seasonal conditions from almost nothing to as much as 400,000 lb. of seed, the average annual yield being approximately 250,000 lb.

COLONIAL BENT (*Agrostis tenuis*) and CREEPING BENT (*Agrostis stolonifera*): Colonial bent seed is harvested mainly on Prince Edward Island, where the annual



Map showing the areas in western Canada where grass and legume seeds are being produced.

production is about 10,000 lb. A small quantity, about 4,000 lb., of creeping bent seed is harvested each season in New Brunswick.

OTHER SEEDS: Western Ontario produces about 200,000 lb. of millet seed annually and one district in Quebec harvests approximately 200,000 lb. of spring vetch.

The authors desire to acknowledge the assistance of Mr. G. S. Peart in preparing the information on the statistics of forage crop seed production in Canada.

[To face p. 175

[See opposite page for description.]

ROOT STUDY TECHNIQUE

E. Obermayer

M. Kir. Alfoldi Mezögazodasagi Intezet, Szeged, Hungary.

The Royal Hungarian Crop Production Research Station at Szeged is concerned with research relating to the continental climate of the great Hungarian lowland plain.

Under conditions here, both the crop plants of the arable land and the herbage plants of the grasslands must be of a xerophytic nature, except in the case of the irrigated regions.

The set of concrete cells illustrated in the accompanying photographs, consisting of eighteen individual cells each 150 cm. deep and 60 cm. across, has been designed for the observation of this capacity in crop plants, especially in grasses and clovers. Each cell has four easily removable concrete doors, arranged one above the other but independent of each other, by means of which the development of the root system is controllable throughout the whole course of growth. At any given point during growth, or at the end, the roots can be washed out. The water and soil are carried off through the concrete corridor between the cell rows and a broad concrete channel into a drain close by. The corridor is sufficiently wide to enable the root systems in the different cells to be photographed.

PROPAGATION OF CUTTINGS OF HERBAGE PLANTS BY MEANS OF GROWTH-PROMOTING SUBSTANCES

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Most herbage plants are fertilized by cross-pollination, and thus even improved varieties or strains represent more or less heterozygous populations. In their breeding it is necessary (1) to test the selected individual plants, and it is desirable (2) to obtain as many seeds as possible of those types which are proved to be superior or outstanding. Both objectives may be attained if the selected plants are propagated vegetatively before testing. Unfortunately, however, many herbage plants do not spread vegetatively and their propagation by cuttings is not always easy.

Westage and Oliver (1937) were the first to undertake a large-scale vegetative propagation of lucerne, and they mentioned that their method had also been successful with red clover.

Vasters (1913) rooted his red clover cuttings in a cold frame; after planting in June, flowering plants were obtained in the same year. He found that the lower parts of the shoots formed roots more readily than cuttings from the centre and more particularly from the top of the shoot. As only 44 per cent of the cuttings from the lowest part of the shoot and 2 per cent of the top cuttings formed roots, he concluded that red clover was a difficult plant to propagate vegetatively.

In his study on Russian cultivated clover, Lisicyn (1925) describes a method whereby as early as 1911 he succeeded in propagating red clover by cuttings. In 1918 he used a special small glass-covered hot bed, in which 96 per cent of the cuttings taken during April and May and kept at 15 to 20°C. in a diffuse light and high humidity formed callus within 4 to 5 days and had rooted sufficiently in 3 to 4 weeks to be transplanted in the open. As cuttings he used young spring branches of the rosette, 6 to 8 cm. long (with leaves), which had not yet developed a full internode; by this method he was able to obtain up to 50 plants from one mother plant.

Fruwirth (1929) mentions that in his experiments in the open 60 per cent of the cuttings from young shoots and 50 per cent of those from flowering shoots were successful.

According to personal information, Mostovoj (1929) in the Seed Testing Station, Brno, propagated lucerne and coumarin-free sweet clover (*Melilotus*) by cuttings obtained from soft (not woody) branches, cut into sections, each with one internode, and kept on moist sand in a humid atmosphere. Six lucerne varieties were tested, and a variation between varieties in the capacity to form callus and roots was noted. It was more difficult to obtain roots from sweet clover than from lucerne. The

rooted cuttings were planted in a mixture of 50 per cent garden soil and 50 per cent sand ; after new branches had been formed further cuttings were taken, thus making it possible to obtain a large number of the vegetative progeny.

Vegetative propagation of grasses which do not spread by stolons is mostly done by division. As far as we know, propagation by cuttings has not been practised.

In 1929, Mostovoj induced root development at the nodes of barley culms, which were placed in glass tubes filled with moist peat. Roots appeared on the nodes and new shoots developed. Thus the culms could be cut into several rooted segments, which finally developed into perfect plants. A similar method, combined with a type of layering, was used by Pogosjan (1927) for the vegetative propagation of wheat. Moist filter paper was rolled round the nodes of the wheat culms which developed roots and new lateral shoots within 10 to 15 days. If these secondary shoots, each with 2 to 3 leaves, were planted like cuttings in moist soil they formed roots and developed after transplantation into normal fruiting plants in the same year. Several cuttings may be obtained in succession from one internode, and thus 100 plants or more may be obtained from a single mother plant.

Although the results mentioned have been obtained on cereals, it does not seem impracticable to apply a similar method to forage and meadow grasses which form tufts and do not spread.

From the experiments quoted it is evident that the difficulty of propagating herbage plants vegetatively is not so great as has been thought. If a proper method is adopted and the correct season chosen, good results may be expected, especially nowadays when, in addition, growth substances may be used.

The use of growth substances in the propagation of cuttings is a recent development. Since the discovery by Boysen-Jensen (1910) of the existence of a growth-promoting substance, numerous theoretical studies dealing with this subject have appeared. The complete history of this research may be found in the books by Boysen-Jensen (1935), Schlenker (1937), Went and Thimann (1937), etc. The application of growth-promoting substances to plant propagation has been studied by Laibach (1935) and his school, and particularly successfully by the workers of the Boyce Thompson Institute for Plant Research at Yonkers, New York (Hitchcock, Zimmermann and Wilcoxon, 1935, 1936, 1937). These last authors were the first to apply growth-promoting substances to cuttings basally in solutions and not in the form of paste as used by Laibach (1935). This practical method gave such good results that almost at once throughout the world it was introduced into practice, particularly in horticulture. Tincker in England (1936a, 1936b), one of us in Bohemia (Scholz, 1937) and numerous other authors elsewhere (Komissarov, 1938, Evenari and collaborators, 1938, Van der Lek, 1937, Gočolašvili and Maksimov, 1937, and others) used this method with success on cuttings of garden and forest plants.

There are, however, only a few studies dealing with the application of growth substances to cuttings of herbage plants. In fact, only Burton (1936) tested the method of Zimmermann and Wilcoxon (1935) on lucerne cuttings, obtaining very good results with indole-3-acetic acid and alpha-naphthalene acetic acid. Heteroauxin

was applied in a water solution at a concentration of 50 p.p.m. for a period of 5 to 10 minutes. Naphthalene acetic acid synthetized from naphthalene and probably containing an impurity of the ineffective beta-form was used in an unstated concentration. The favourable effects of both substances are reported, the naphthalene acetic acid being superior. Both substances produced a more or less earlier formation of roots on cuttings. In some cases a higher percentage of rooted cuttings was obtained. The tip cuttings formed longer roots and rooted more frequently than cuttings taken lower down the stem. Varietal differences in rooting capacity were observed; Hardigan produced more and better roots than Hairy Peruvian. There were even morphological differences in the growth habits of the roots: Hardigan formed more horizontal roots, Hairy Peruvian more perpendicular roots.

Without knowledge of this study, one of us (Šmidrkal 1938) tested the reaction of Moravian lucerne, red clover and *Onobrychis sativa* to the following growth-promoting substances (received from the British Drug Houses, Ltd., London): alpha-naphthalene acetic acid, beta-indolyl-acetic acid (or indole-3-acetic acid = heteroauxin) and beta-indolyl-propionic acid. Two concentrations of these substances were used on lucerne, namely, 10 and 20 mg. per 100 ccm. solution. On red clover and *Onobrychis* only the lower concentration was used. Lucerne cuttings were taken on April 18, red clover and *Onobrychis* on May 19. Cuttings taken from one plant were placed upright to a depth of 3 cm. in the solutions for 24 hours, the control cuttings remaining for the same time in pure water. They were then rinsed in water and planted in sand in a cold frame. Three weeks later they were inspected and transplanted in the field. All treated cuttings formed numerous roots, while only 40 per cent of the control cuttings developed scanty roots and 60 per cent formed slight callus or died. Judging by the number and length of roots formed, the lower concentrations (10 mg. per 100 ccm., were more effective (Figs. 1 and 2)). Naphthalene acetic acid was superior to both other substances tested. During the rooting stage the increase in length of shoots of red clover was considerable, while lucerne showed less increase and *Onobrychis* very little. The treated cuttings increased strongly in the field, blossomed in the same year and produced good seed. They also formed numerous nodules, which later disappeared. The rooted controls became established with difficulty in the open, the foliage being a yellowish-green colour for a considerable time and little seed being produced. The root system of a treated cutting inspected in September (Fig. 3) showed numerous strong roots, but no tap root.

The favourable effect of growth substances was thus proved for lucerne, red clover and *Onobrychis*, and there is little doubt that other herbage plants will react similarly. It is, however, advisable to test several increasing concentrations of the substances at the beginning, because not only different species, but even different varieties require different concentrations in order to produce an optimum effect. According to our experiments with other plants, the degree of ripeness is very important. Some plants give best results when soft cuttings are taken, while with others ripened or half-woody cuttings are required for the maximum effect, even if growth substances are applied.

Fig. 1.

Fig. 2.

Fig. 3.

Only a few experiments have been conducted so far with monocotyledons which, apparently, give a slightly weaker reaction to growth substances. Unpublished experiments of Jakeš in the Prague Institute for Meadow and Pasture Plants indicate, however, that cuttings of *Agrostis alba stolonifera* produced more roots after the application of growth substances.

According to unpublished results in the Institute of Horticultural Research at Průhonice, the proprietory preparations such as "Seradix A" of May and Baker, Ltd., "Roche 202" of Hoffmann-La Roche, Basel, Switzerland, and "Belvitan" I. G. Farbenindustrie, Leverkusen, have yielded even better results with ornamental plants than the pure chemicals. They are delivered in concentrated solution or in a water soluble powder, which is an advantage compared with the pure acids which have to be dissolved in a few drops of ethyl alcohol before being diluted with water. It is still necessary, however, to find the optimal concentrations for herbage plants, as these have not yet been tested sufficiently. Results on other plants in comparison with heteroauxin indicate that for Seradix A and Roche 202, which are supplied in solution, the optimal dilution will fluctuate from 1 to 10 ccm. of the original solution per litre of water and with Belvitan from 10 to 100 mg. per 100 ccm. water.

It may be expected that the use of growth-promoting substances in the vegetative propagation of herbage plants will facilitate considerably the work of the plant breeder and possibly also other activities, such as the establishment of turf from treated grass cuttings, which might become a practice in countries with suitable climatic conditions.

FIG. 1.—Cuttings of Moravian lucerne 21 days after treatment for 24 hours in :—

		Mg. per 100 cc. water.
I	alpha-naphthalene acetic acid	10
II	do.	20
III	beta-indolyl-acetic acid	10
IV	do.	20
V	beta-indolyl-propionic acid	10
VI	do.	20
O	Control in water.	

FIG. 2.—Cuttings of red clover and *Onobrychis sativa* 21 days after treatment for 24 hours in :

		Mg. per 100 cc. water.
I	alpha-naphthalene acetic acid	10
II	beta-indolyl-acetic acid	10
III	beta-indolyl-propionic acid	10
K	Control in water.	

FIG. 3.—Root system of a cutting of Moravian lucerne treated on April 18, 1938, and photographed in September, 1938.

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REVIEWS

PHASIC DEVELOPMENT OF PLANTS (3)

A review recently prepared by the staff of the Imperial Bureau of Pastures and Forage Crops, and published under the authorship of R. O. Whyte, *Biol. Rev.* 14. 51-87. 1939, is being summarized and supplemented in serial form in the four issues of *Herbage Reviews* for 1939. The first discussions appeared in the March and June issues, pp. 27-32 and 94-9 respectively.

A translation of a review of the above article by M. A. Bassarskaja is reproduced on p. 189.

Developmental Period and Evolution

It would be presumptuous to consider these conclusions as exhaustive or final; they do not so much solve questions as raise them, but at the same time they do suggest direction for future research.

The fundamental conclusion is that the developmental period consists of a sequence of ecologo-physiological phases, that is, a complex of qualitative changes, each of which can be completed under definite external and internal conditions. The existence and succession of these ecolo-physiological étapes, at least in the life of herbaceous plants, have been established ecologically, and also with less certainty physiologically, as well as in genetical studies, in which it has been found that the developmental phases hitherto established are inherited independently of each other and segregate most diversely in the progeny. Each of these phases "is a biological character acquired in the evolutionary differentiation of forms"; consequently in higher terrestrial plants, which have passed through a more or less common succession of evolutionary changes, ontogenetical phases "must be similar in their main outlines and must follow one another in the same hereditarily determined order" (Cholodny, 1939). Those adaptive changes which arise in the acclimatization both of individuals and of forms, species and genera (natural selection) have concerned chiefly the length of the individual phases and their adaptation (tolerance and requirements) to the environment, and apparently did not, or only rarely, affect the succession of developmental phases.

It is not a bare speculation. In support may first be quoted the experiments of Lysenko (pp. 81-2 of the review) on the conversion of "spring" forms into "winter", "winter" forms into "spring", and "short-day" into "long day". This is unmistakably suggested by the diversity of forms in one and the same species, including all gradations between "winter" and "spring" types and "long-day" and "short-day" types. The ease and rapidity with which these "adaptive changes" occur would suggest that they are of a quantitative rather than of a qualitative nature. In other words, the training of plants (pp. 81-2 of the review) transposes them from one "quantity" to another, whereas vernalization transfers them from one "quality" to another.

Therefore, "spring" and "winter," "late" and "early" are of the same kind,

whereas " vernalized winter or late " plants differ in quality from " unvernalized spring or early," as well as from " unvernalized winter." Hence, any attempt to draw a parallel or establish a similarity between " spring " and " vernalized " plants is certainly misconceived.

More attention should have been given to " the physiological cause of vernalization " in the review (pp. 71-9), not only because the earliest physiological (" winter " and " spring " hormones, enzymes, etc.), and morphological (differentiation of terminal bud) investigations of vernalization were based upon this kind of misconception, but also because some investigators still persist in advocating a sameness between " spring " and " vernalized winter " plants (for example, the " number of leaf " hypothesis held by Gregory and Purvis). Once again : vernalization does not " convert a winter rye into a spring rye " as Purvis (1939) deduced, not even " within one generation," nor does " it induce in a winter rye a physiological condition leading to early flowering which is already inherent in spring rye," as during vernalization, regardless the type of plant, there occurs a transition from one developmental phase (the thermo-phase) to another.

Length of the Thermo-Phase

We have already pointed out an interesting regularity in respect of the thermo-phase, namely, the higher is the temperature of vernalization, the shorter the period of vernalization, that is, the time required to complete this phase under the optimum temperature. In other words, the higher are the cardinal points of temperature, the shorter is the phase. Moreover, investigations of the thermo-phase in cereals " led to the establishment of a dependence of the length of this phase upon the primary place of origin " (Vavilov, 1935). For instance, Mediterranean forms of cereals possess a longer thermo-phase and require lower temperatures at this phase than the northern forms. Undoubtedly, Vavilov is correct in saying that " this kind of geographical dependence shows that the requirement for a definite condition for vernalization appears to be an intimate physiological character linked with the origin and evolution of forms." It would then follow that in the process of evolution there was a differentiation of " winter " and " late " forms into " early " and " spring " forms, and this process was associated with a curtailment of the thermo-phase and a rise in the cardinal points of temperature. Thus :

winter (late) ⟶ spring (early),
long thermo-phase ⟶ short thermo-phase,
low temperature ⟶ high temperature,

as wheat spreads northwards.

Such an evolution is hardly plausible. It would be more probable for adaptation to higher temperature to be compensated by prolongation of the thermo-phase. Something of this type was detected by Koreïša (p. 69 of the review) in lucernes of different geographical origins, namely, northern types which must be more tolerant of day length required a greater number of short days to attain flowering (prolongation of light-sensitive phases) than the southern types. As will be shown later, this kind of schematization is somewhat presumptuous and certainly " calls for a thorough revision of the conclusions hitherto made regarding the relative response of plants to vernalization and the degree of their lateness."

Response to Vernalization

As a matter of fact this schematization is based upon the " response to vernalization " as established in numerous tests made on rather too broad lines, hundreds

of varieties being vernalized according to a common scheme, and the time of earing being regarded as a criterion of the degree of response to vernalization. In these investigations it was indeed established that there are many strains, varieties and species which show little or no response to vernalization, vernalized plants flowering, if at all, more or less at the same time as the unvernalized control.

We shall quote below some examples taken from recent work of Vasiljev (1939) in which the conditions of vernalization were much more " specialized " than elsewhere. Among wheats, early hard forms and soft forms did not respond to vernalization ; no response, or a very insignificant one, was typical of all spring and early oats and barley. Millet and timothy showed no response to vernalization, while ryegrass, fescue and cocksfoot flowered after vernalization in the year of sowing. The vegetative period of annual lupins (*L. angustifolius*, *L. luteus*, *L. albus* and *L. succulentus*) was shortened after vernalization by anything from 5 to 30 days, and yet *L. polyphyllus* failed to respond to vernalization of seed, although this species did respond to vernalization of plantules. *Vicia villosa* flowered 14 to 24 days earlier after vernalization, but *V. picta* responded to vernalization of plantules only. In *V. sativa* southern forms, as distinct from northern, showed little, if any, response to vernalization (Table 1). *Phaseolus*, small-seeded beans, annual and perennial *Helianthus*, *Carthamus*, tobacco and red clover failed to respond, while cabbage, tomatoes, turnips, swedes and beetroot responded only to vernalization of plantules. *Lathyrus*, *Lens*, *Pisum* and brown-seeded beans contained forms which responded to vernalization ; vernalized serradella plants flowered 10 days earlier.

Table 1 : Response to vernalization of *Vicia* varieties of different origin

Variety	Flowering earlier than the control. (in days)
Shatilovo 406	15
Shatilovo 399	3
Saratov 253	1
Germania 175	14
Tunis 199	1
Italia 219	1

All these examples are interesting, but as yet are of no value, or at least are not reliable to convey an idea of the relative length of the thermo-phase. In the first place, vernalization is not only chilling of seeds, as considered by Vasiljev and some other investigators, and the optimum range of temperatures required varies widely with forms and strains of the same plant, not to mention the species, as pointed out on p. 59 and elsewhere in the review. We shall not dwell upon the merely " technical causes " of lack of response to vernalization, such as the chilling of seeds of lowland southern forms ; instead we shall quote some results of Vasiljev on vernalization of the same variety of lupin (Table 2) and vetch (Table 3) to show how far one can rely upon the " response to vernalization " of plants vernalized at the same temperature, regardless of their origin, and we shall consider those internal and external causes of failure which have hitherto not been taken into account.

Table 2 : *Lupinus angustifolius*

Temperature of vernalization (in °C) :	15	10	5	0-2	0-2	Control
Period of vernalization (in days) :	15	18	22	36	50	—
Vegetative period in 1935 (in days) :	45	34	27	—	—	45
Vegetative period in 1937 (in days) :	—	—	37	35	35	48

Table 3: *Vicia sativa*: **variety Shatilovo** 406

Temperature of vernalization (in °C):	15	10	5	5	0-2	0-2	Control
Period of vernalization (in days):	13	16	13	26	37	45	—
Vegetative period (in days):	37	34	34	31	28	28	38

It was pointed out in the review (pp. 59, 62-3, 69-70 and elsewhere) that the curtailment of the vegetative period depends both upon the physiological state of the terminal bud, that is, whether the thermo-phase was fully or partly, if at all, completed during vernalization, and upon the environmental conditions in which the plant develops after sowing, that is, how far these conditions would facilitate the progress of each of the subsequent phases. On pp. 63 and 69-79 and elsewhere, examples were quoted to show how erroneous conclusions may be if the "response to vernalization", much less the length of the phase, is measured by the time of flowering. "A more accurate idea of the length of the first phase (or more correctly the response to vernalization—M.A.O.) can be gained when seeds vernalized for a varying number of days are grown after simultaneous sowing under conditions suitable for subsequent development"—advice that would appear to be true, but difficult to accomplish as it is just these conditions about which so little is yet known. The only reliable method, at least on an experimental scale, would indeed be the biochemical (physiological) test of the terminal buds on the lines suggested by Bassarskaja (p. 76) and, perhaps, also "morphological detection" based upon the rapidity of differentiation of the terminal bud (Krasnoseljskaja—Maksimova *et al*, 1933), the vigour of leaf appearance and growth (Sereïskiĭ and Sludskaja, 1934; 1937) and the number of leaves (Gregory and Purvis, 1938), of which nothing is said in the review, but these methods must be carefully checked before being adopted as the last two are hardly compatible.

But this is not all. "Kostjučenko and Zarubaĭlo, and later Gregory and Purvis, showed that if ripening seed of winter cereals had experienced low temperature . . . . the resulting plants would attain earing when grown continuously at high temperatures. As vernalization of this seed had no effect on time of earing, it was concluded that under certain conditions . . . . this stage can be completed during seed ripening . . . . This led to the conclusion that if in winter (late) forms this phase can be completed in special circumstances during seed ripening, then in other forms, particularly those requiring relatively high temperatures (spring cereals and the short-day thermophytes), that phase may be fully or partially completed during seed ripening each year. In any event it may be said with certainty that the possibility of completion of the thermo-phase is greater in short-day thermophytes (millet, cotton) than in long-day cereals, and in spring forms as compared with winter forms. It seems safe to assume that the shortness of the thermo-phase in short-day plants may be due merely to the full or partial completion of that phase during seed ripening. . . . . In winter (late) cereals requiring low temperature, the completion of the thermo-phase during seed ripening is of less frequent occurrence and regularity than in spring (early) cereals, which require relatively higher temperature at that phase; in the latter the subsequent phase, requiring high temperature and darkness, may also be fully or partially completed, with the result that the vegetative period begins either from the end of the 'dark phase' or even from the 'light phase', thus affecting the relation of plants to day length" (Whyte and Oljhovikov, 1939) and indeed to other environmental factors and consequently to vernalization.

Therefore, although it would appear to be true that "not all plants contain the stage of vernalization in their individual development . . . . there are many

plants in which this stage is absent", this is not because, as Vasiljev (1939) and some other investigators argue, Lysenko's theory is at fault in maintaining "that the stage of vernalization is a general biological stage of individual development, that is, a stage inherent to a large group of plants (at least to all seed plants)," but because, owing to environmental conditions during seed ripening, this phase was completed fully ("absent"), or partially ("short") in the embryo tissues before the seed ripened and dormancy set in. Naturally, after seed germination these plants will not require the conditions specific to the thermo-phase, but will continue their development, which was interrupted by dormancy. Therefore, in tests of the "response to vernalization" it is first necessary to ensure that the thermo-phase has not been fully or partially completed during seed ripening. These absolutely indispensable precautions have not been taken into consideration in any of the tests known to us, other than those reported by Kostjučenko and Zarubaĭlo.

We have already pointed out another possible cause for lack of response to vernalization, namely, in certain plants it is not impossible that during seed ripening the embryo tissue may fail (owing to environmental conditions) to complete the phase or phases preceding the thermo-phase, that is, to advance in development (quality) so far that the thermo-phase will follow directly after germination; the "first phase" (thermo-phase) is by no means the first phase in the "individual development of plants from seed to seed." This occurrence may explain why vernalization of seed fails and yet the plantules respond readily to vernalization.

There is still another possibility. There is by now ample evidence to show that development ceases when the afflux of nutrients to the terminal bud is inadequate. It is quite possible that in the case of small-seeded plants the thermo-phase cannot be fully completed before reserve nutrients of the seed are exhausted and "a certain physiological state of the embryo with the capacity to grow and develop" is discontinued. Such a failure has been recorded repeatedly in the vernalization of excised embryos of cereals on distilled water. The thermo-phase can be vernalized completely and without interruption in small-seeded plants, either with artificial nutrition, or in green plants capable of ensuring normal assimilation.

The Length of Subsequent Phases

It is still more difficult to detect the relative length of the two subsequent light-sensitive phases. Little is yet known of the optimum conditions for completion of these phases in different biotypes; the environmental complex required is greatly complicated by the light factor, that is, its quantity (intensity), quality (wave-length), and duration (photoperiod). Several examples are given on pp. 69-70 of the review to emphasize the importance of accounting for the entire complex of acting factors, and particularly temperature.

Since the discovery of the sensitiveness of plants to diurnal photoperiods, this aspect has been repeatedly stressed, for example, by Eaton (1924) and Gilbert (1926). The significance of temperature was clearly demonstrated by Dolgušin (1932), described on pp. 66-7 of the review, and by Hamner and Bonner (1938). The same conclusion may be deduced from Razumov's experiments (1935), described on pp. 67, 69-70, and elsewhere in the review.

Another important aspect is the physiological state of the plant before, during and after test, that is, the developmental phase at which a plant is tested. Čaĭlahjan (1937) and Moškov (1939b) emphasized also the importance of "the age" of the plants, or more precisely their "morphological fitness" (the presence of physiologically potent leaves). One must, however, be careful in adopting this view, as these investigators, more particularly Moškov, seemed to ignore the physiological state of the plants. In the latter's experiments with *Perilla*, the plants showed

little, if any, sensitiveness to seven days' induction with short day during the first 15 to 20 days after germination. Thus, in experiments with *P. nankincnsis*, plantules at the age of 1, 5 and 10 days did not respond to the induction (failed to flower in long photoperiods) ; 15 to 20 day-old plantules flowered in long photoperiods in 22 and 21 days after the induction, and yet all older plantules (25 to 45 days), regardless of their age, flowered in 18 days after induction.

Does the cause of this behaviour then lie merely in the leaves? Does it not suggest also that the failure of young plantules to respond to short photoperiods may be traced to the developmental phase during the first 10 or 14 days, only subsequent to which the plants acquired the physiological faculty to utilize the short-day induction for reproductive purposes ? That is, the first 10 or 14 days were required to complete the thermo-phase, when it could not conceive short-day induction, then during the 7-day induction to pass through the subsequent " dark phase ", and afterwards to complete their development in long days. In other words, can an analogy be drawn between this experiment and those described on p. 65 and elsewhere in the review, where unvernalized and under-vernalized wheat plants, regardless of their age, failed to respond to long photoperiods, whereas vernalized plants of the same " age " responded readily ?

Actually, the leaves were of no importance in experiments with the induction of seeds of " short-day " plants in darkness (Ljubimenko and Ščeglova, 1931), and in the vernalization of seed of " short-day " plants in darkness, short days and long days (Lysenko, 1931), as described on p. 66 of the review. Of course the mode of the response of the embryo living on food stored in the endosperm and that of green plants elaborating food from outside must differ, but one must not fail to see the wood for the trees. It undoubtedly varies also with the biotypes, for how can we otherwise approach on the basis of this " leaf theory " plants which flower before the leaves unfold ?

We have emphasized again and again the primary importance of the physiological state of the plants which appears as a result of their preceding history, beginning with and during embryogeny, but this all important aspect has been overlooked hitherto, or has been given quite insufficient attention in all environmental studies.

Therefore, in order to obtain any idea of light sensitiveness, it is essential to account for the internal and external factors as accurately as possible. Such studies have yet to be made, and consequently any speculation regarding the length of these phases and their correlation with the origin of the plants would be at the moment too presumptuous, both for " long-day " and " short-day " plants and for " winter " and " spring " forms.

The Dark (Scoto-)Phase a General Biological Phase in Ontogenesis

In earlier studies of the response of plants to the environmental factors governing their transition through the so-called photo-phase in long-day plants (wheat and other cereals), as quoted on pp. 65-70 of the review, the requirement of these plants for darkness (the " dark " phase or scoto-phase if the nomenclature is kept uniform) was not accounted for. Although apparently long in " short-day " plants, that is, requiring a longer period of darkness and less tolerant to intermittent light, this phase is shorter in " long-day " plants. The length of this phase, however, also varies considerably in the latter plants and seems to be longer in " winter " forms than in " spring " forms. However, if one is to account for the reports of Eghiz (1938), Volk (1936), Abukumova (1938) and others, the possibility of the full or partial completion of this phase during seed ripening and later during germination after sowing must not be overlooked, particularly when dealing with biotypes endowed

with a short preceding phase; such a hitherto uncontrolled vernalization may be a matter of much more frequent occurrence than formerly thought possible, and has in fact been observed during the last two or three years in many plants besides cereals (cotton, lupin, beet, cabbage and peas).

The discovery of the scoto-phase in "long-day" plants may be said to have reconciled many disputable problems. In the first place it has revealed the cause of the "lesser sensitiveness" of "winter" plants to the prolongation of day-light, which, with various interpretations, has been suggested repeatedly as a criterion for the physiological discrimination between "winter" and "spring" forms. It can now be seen that the cause of this apparent lesser senstiveness of winter cereals consists in that any prolongation of day length beyond the critical, while accelerating the subsequent photo-phase, retards the rapidity of the scoto-phase; hence the total length of these two phases is little, or at least less, changed than in "spring" forms, in which the scoto-phase, if not actually shorter, is more tolerant to day length (a higher critical photo-period). The difference is, therefore, in "quantity," and there is no hard and fast line between plants with a long or short scoto-phase respectively.

The discovery of the scoto-phase, which itself is by no means more or less decisive than any other phase, has been utilized to remove another hard and fast demarcation in the plant kingdom, namely, the division (as defined in photoperiodism) between "long-day" and "short-day" plants, thus making it possible to obtain a rudimentary idea of the general route of plants in sexual development.

The general succession of developmental phases, at least in herbaceous terrestrial plants, appearing as a digest of the many conflicts and divergencies of opinion in plant science, is not so unexpected as would appear at a glance. Indeed, one could list a number of investigators who anticipated it on different grounds, all of which could, nevertheless, be incorporated within the framework of the theory of phasic development. Lysenko and his immediate associates, including the discoverers of the scoto-phase (Eremenko, Mackov, Šimanskiĭ and Trigubenko) failed to reveal the ecologo-physiological differences between the photoperiodical groups of plants; in fact, Lysenko and his associates, in denouncing photoperiodism, re-introduced this division in an even more accentuated form.

Photoperiodism and Phasic Development

Some twenty years ago a new multipotent environmental factor in the life and distribution of plants was discovered, or rather rediscovered by Garner and Allard (1920), which, although opening up a most attractive field of research in plant biology, nevertheless failed to decipher the true relationship of plants to relative length of day and night. The first evidence of this failure was indeed provided by the so-called photoperiodic after-effect, which, although detected by Garner and Allard (1923), did not receive due consideration until it was rediscovered by Eghiz (1928) and extended to "long-day" plants by Razumov (1930). The fact that plants which experienced the "formative photoperiods" for a limited period would flower in the "antagonistic" photoperiods alone suggests that plants do not require a constant photoperiod throughout their life-time; on the contrary, the formative action of a definite photoperiod becomes evident only when it operates during a definite period of plant-life; outside this relatively short life period it either has no effect, or even retards the formative processes. Thus, in Moškov's experiments (1939b) with *Perilla* plantules, 7-day induction with short photoperiods had no effect on young plantules, although the induction was effective with older plants; in Čaĭlahjan's experiments with millet (1937), 7-day induction with short photoperiods, as compared with the control in long photoperiods, delayed flowering of plants more than 42 days old,

speeded up flowering in plants less than 14 days old, and had less effect and finally no effect on the time of flowering as the plants grew older; further evidence and interpretations to this effect will be found on pp. 63-4, 66-7, 71-2 and elsewhere in the review.

Furthermore, the investigations of Ljubimenko and Ščeglova (1931) on the induction of growing seeds of "short-day" plants with a relatively short period of continuous darkness, and more particularly Lysenko's research, including early experiments with the vernalization of "short-day" plants in darkness and in short and long photoperiods, showed, moreover, that it is not the action of the photoperiods as such which is in question, but the action of light and darkness. "No requirement for photoperiods is inherent in the nature of plants . . . Photoperiods do exist . . . but only in the nature of regions . . ." Lysenko reached these conclusions in 1932, Hamner and Bonner in 1938, and others between these dates.

This, however, does not yet clear up the conspicuous behaviour of plants in the records of photoperiodism, particularly such "narrowly-specialized" plants as *Mikania*, *Tephrosia*, *Xanthium*, *Arachis*, *Perilla* and others, which could be regarded as being endowed with two critical photoperiods on either side of the optimum, in which, as far as *Perilla* is concerned (Moškov, 1939a), the dark period "should be two and a half or three times as long as the light period."

The discovery of the scoto-phase in such a typical "long-day" plant as wheat provided a basis for Whyte and Oljhovikov (1939a and b), not only to remove any "qualitative" demarcation between the alleged long-day and short-day plants, but also to propose a single succession of ecologo-physiological phases common to all herbaceous plants hitherto studied, regardless of their photoperiodic class or place of origin; at least a part of the developmental period of a plant may be represented thus:

. . . . . ——→ *thermo-phase* ——→ *scoto-phase* ——→ *photo-phase* . . . . .

Critical Photoperiods

According to this hypothesis, the difference between genera, species, varieties and forms in their relation to photoperiods consists merely in the relative length of these two light-sensitive phases, that is, the total duration of the "formative factors," and tolerance of its intermission by the "antagonistic factors." Consequently, some plants can pass through this photo-phase only in very short photoperiods, while others may complete it more or less easily in relatively long photoperiods; again, some plants may complete the subsequent photo-phase only in very long photoperiods, while the others may pass more or less rapidly through this phase in relatively short photoperiods.

Thus, in the relation of plants to photoperiods during this light-sensitive period two critical photoperiods may be recognized, one, if too long, inhibiting the scoto-phase, and the other, if too short, the photo-phase. The "narrowly-specialized" plants provide an excellent example. These two critical photoperiods limit the range of diurnal photoperiods, in which a plant can complete either of these light-sensitive phases, but only when the photoperiod critical for the photo-phase is shorter than the critical for the scoto-phase. Otherwise, that is, when the possible photoperiods for the scoto-phase and those for the photo-phase do not overlap, the plant will fail to flower if grown in the same one photoperiod, either because the scoto-phase could not be completed (too long photo-period), or because the photo-phase could not be completed (too short photo-period), or because neither of these phases could be completed (photoperiods shorter than the shortest possible photoperiod for the photo-phase and longer than the longest possible photoperiod for the scoto-phase). Accordingly, it was concluded (Whyte and Oljhovikov, 1939b) that "the 'fairly

definite optimum length of day for flowering' (Garner, 1933) appears, therefore, to be only a kind of compensatory photoperiod, that is, least retardative for the dark-phase as well as least retardative for the light-phase." In some plants this "compensatory" range of possible photoperiods is fairly long, in others fairly short, or even absent altogether. This may be illustrated by examples from recent investigations.

In experiments with *Arachis* (Čeljadinova, 1937), African forms failed to flower in 6, 10, and 14-hour photoperiods, while the other two varieties flowered most rapidly in a 10-hour day, flowering being delayed when this photoperiod was changed in either direction. It is evident that the cause of the failure of the African varieties to flower, and of the conspicuous delay in flowering of the other two varieties in 6 and 14-hour photoperiods was physiologically different, as may be explained on the basis of the conception of critical photoperiods, outlined above (Whyte and Oljhovikov, 1939b), the acknowledgment of ecologo-physiological phases distinct in their relation to light and darkness being presumed.

Again, Hamner and Bonner (1938) have shown that *Xanthium pennsylvanicum* failed to flower in a 12-hour cycle when the photoperiods were reduced to 4 hours, but were followed by 8 hours darkness, the critical photoperiod (in Garner's definition) being a 16-hour day. Yet the plants did flower in 9 and 15 to 16-hour diurnal photoperiods, and in 16-hour photoperiods followed by 32 hours darkness in a 48-hour cycle. The internal cause of the behaviour in these photoperiods must again obviously be different and the conclusion that it is "a response to duration of the dark period" and not to the succession of dark and light periods would not appear to be fully warranted.

It must be added that the light-sensitive period under discussion, namely, the scoto-phase and the photo-phase, is not the only period at which plants respond to photoperiods. This can be deduced from the discovery of the subsequent "third" phase, at which plants are endowed at least with a relation to photoperiods unmistakably distinct from that exhibited at the preceding sensitive phases.

If confirmed, this common succession of ecologo-physiological phases, combined with a new interpretation of critical photoperiods, be utilized to reconcile many apparent conflicts in ecology and physiology, and offers an interesting and promising field for future research.

REGARDING "PHASIC DEVELOPMENT OF PLANTS"

A review recently prepared by the staff of the Imperial Bureau of Pastures and Forage Crops, published under the authorship of R. O. Whyte, *Biol. Rev.* 14. pp. 51-87. 1939, has been favourably reviewed by Dr. M. A. Bassarskaja, a close assistant to Academician T. D. Lysenko, in *Jarovizacija*, No. 2 (23), pp. 141-2, 1939, a journal on the biology of plant development, published at the Institute of Plant Breeding and Genetics, Odessa, under the editorship of Academician T. D. Lysenko and Professor I. I. Present. A translation of this review is given below by courtesy of the Editors and the Reviewers.

"During recent years a number of articles appeared in the annals of foreign specialist journals which dealt with various problems pertaining to the theory of phasic develop-

ment, as formulated by Academician T. D. Lysenko. These attempts testify to the great interest which is being given to the research of Acad. T. D. Lysenko. Unfortunately, the theoretical bases of vernalization remained inexplicable and intricate to many investigators. These investigators usually considered the stage of vernalization not as an indispensable étape in the life of a plant, the environmental requirements of which have been settled historically, but as a stimulation curtailing the vegetative period. It is by these misconceptions that one can explain the numerous vain essays and researches carried out by them in relation to vernalization.

" The paper published by R. O. Whyte differs creditably from these attempts. The writer gives a critical survey of ' the facts and principles upon which the theory and practice of vernalization have been based.' The literature quoted is not, of course, exhaustive. Only that which, in the writer's opinion, was most substantial was used by him.

" The entire paper is divided into eight chapters in which the problems of phasic development of plants are examined step by step.

" In the first chapter Whyte gives the general outlines of the theoretical bases of plant development as formulated by Acad. T. D. Lysenko. In the first place the writer draws attention to the conception of growth and development, the keystone, as he puts it, to Lysenko's theory, and then to those qualitative changes which occur in the meristematic tissues as the plant passes from phase to phase, and without which ultimate reproduction cannot be attained. The writer is perfectly correct in saying that not all the developmental phases are detectable morphologically and not all the morphological changes appear as an immediate consequence of the transition of the plant from one phase to another.

" Examining the first étape of development, the stage of vernalization, Whyte concentrates attention upon the conditions required for the completion of that stage and evaluates correctly the significance of each. The writer understood that none of these conditions can be regarded separately as determinative, and that for the completion of this stage a certain complex of factors is required which may vary within definite limits. Whyte points out that ' some investigators still fail to realize that vernalization (the writer has in view pre-sowing treatment, M.A.B.) is not a stimulation or induction . . . . . , but only a pre-sowing completion of part of the developmental period . . . . . '

" At a later point, in examining the process of vernalization, the writer concluded that the duration of the stage of vernalization may change with the environment, and is not ' an independent factor, as advocated by some investigators . . . . . Vernalization,' he writes further, ' is a biological character acquired in the evolutionary differentiation of forms.'

" Proceeding to the photo-phase, Whyte emphasizes once more that none of the conditions required can be regarded separately as determining the completion of that phase.

" In a deep and systematic survey of the bases of the developmental theory, the writer proceeds to the questions which he found in the literature, namely, whether the phasic changes are reversible. The author indicates that certain investigators, in attempting to establish the reversibility of these processes, remain unconvincing, and that ' the loss of the properties acquired in vernalization was invariably associated with destruction of the growing point.' Because, as Whyte rightly argues, ' there seems to be no doubt that the internal changes which are responsible for morphogenesis occur and are localized in the meristematic cells of the growing point.'

" As regards the ' hormonal theory ' of vernalization, the writer points out that this ' hypothesis conflicts with the bases of phasic development and with all that is known of vernalization of many plants at high and low temperatures.'

" In summarizing the advances made in the theory of phasic development, Whyte has fully appreciated why the properties of the plant body changes, and hence why Acad. T. D. Lysenko and his associates proceed in their research from quite different genetical positions from those held by Mendelists and Morganists, namely, from the positions of Darwin and Mičurin.

" An examination of Whyte's paper shows that the writer worked seriously upon questions relating to the theory of phasic development. Some of the defects which occur in the paper are most probably the consequence of insufficiently accurate English translations of the articles used in its preparation. For instance, on p. 71, the writer expresses surprise that, in an 8-hour day, wheat plants could give normal fertile pollen and eared at the same time as the control. The writer failed to notice that the plants in question were not transferred to an 8-hour day until after the first and second phases were fully completed.

" It should also be noted that Whyte did not make use of the literature published in 1938."—M. A. Bassarskaja.

Comments

While it is not claimed that the review under discussion is faultless or exhaustive, we feel that it is desirable to reply to the critical note made by Dr. M. A. Bassarskaja.

In examining the photoperiodic response of wheat plants at the " third " developmental phase, as described on pp. 70-1 of the review, we have not overlooked the fact that plants were transferred to short photoperiods from long (continuous) photoperiods, when the preceding photo-phase had been completed. We have noted, however, that these plants " in a 6-hour day produced normal pollen and seeds as rapidly as in a long day," and yet the same plants failed to complete their normal development (pollen was sterile) in a 4-hour day.

On the one hand this behaviour suggests unmistakably that, on the completion of the photo-phase, the plants entered into a new " quality " with a different relation to the diurnal length of day and a different critical photoperiod from that inherent at the photo-phase.

On the other hand, bearing in mind this new " photoperiodism ", the behaviour of wheat plants at the " third phase " in short photoperiods seems to us inconsistent with " Lysenko's conception as to the meaning of long and short day."

We may admit that our conclusion that this " third phase " seems to comprise two phases, distinct in their relation to diurnal day-length, may be presumptuous, in spite of the results announced by E. Larose and R. Vanderwalle (1938), but we do think that the behaviour of wheat plants at the third phase in variously shortened photoperiods deserves a closer study.

As regards the remark that some of the papers published in 1938 were not included, we may mention that the final version of the review was completed and submitted to the editor early in the summer of 1938. In addition, Soviet periodicals become available, according to our experience, only after a considerable and frequently inexcusable delay, a fault which is not entirely ours, as every effort has been, and is being, made to secure normal access to relevant Soviet current literature.—R.O.W.

THE GRASSLANDS OF BRAZIL

[Reviewer: G. M. Roseveare]

In an article entitled "The meat industry in Brazil," published in the State of São Paulo's *Revista de Indústria Animal*, N.s. 2. No. 1. 69-89. 1939, Oscar da Silva Brito, of the Department of Animal Industry, São Paulo, Brazil, gives an account, not only of the past history and present position of the industry, but of the natural conditions which make it of paramount importance in this country. The following is a translation of the section in question, slightly rearranged.

Brazil, with its eight and a half million square kilometres of land, ranging from the equatorial to the subtropical, presents a complete scale of soils, climates, and types of vegetation. The populations of each region are for the most part engaged in agriculture or stock-raising of a nature determined by the very diverse environmental conditions.

Professor J. C. Branner (**1**), speaking of the constitution of the Brazilian soils, says: "the strata ascribed to the Triassic by Orville Derby occupy an extensive area in the central and western part of the Parana basin: Minas Gerais, Mato Grosso, São Paulo and Parana, as well as the Republic of Paraguay; a large part of the basin of the Uruguay, the States of Santa Catarina and Rio Grande do Sul, extending also into the neighbouring Republic of Uruguay. There are no fossils present, and his definition of them as Triassic is based upon the fact of their superposition on the Permian strata, the rocks—especially the eruptive—resembling the Triassic rocks of Europe and of the eastern part of North America."

Professor Paulino Cavalcanti (**2**) expresses the following opinion in relation to the same subject: "It is seen that the soils of Brazil contain a higher percentage of calcium and phosphoric acid than those of France, for the reason that—to a large extent—the eruptive rocks are included in the gneiss formations of Brazil, especially in the State of Rio de Janeiro, the centre of Minas Gerais, Mato Grosso and Goyaz. . . . In addition to the Archaean region of Brazil, which is highly suitable for stock-raising, especially that of beef cattle, others offer still more advantages, such as those in which the Triassic formations predominate, like the centre of São Paulo and the west of Minas Gerais or the Triangle."*

From the opinions above cited it is seen that conditions propitious for cattle farming are afforded by the wide zone extending from the extreme south, the State of Rio Grande do Sul, to the central States, namely, São Paulo, Mato Grosso, Goyaz and Minas Gerais. It is precisely in this zone that the largest ranches and the most important correlated industries are found.

The State of **Rio Grande do Sul,** thanks to its geographic position, profits from a situation almost equal to that of Uruguay and part of Argentina, being likewise situated in a temperate zone, which is the best for the production of the finest qualities of meat and which enables it to comply with the requirements of the market in Great Britain and the European continent. There grow in its campos excellent natural herbage plants, the nutritive value of which satisfies the requirements of the meat chilling industry. Rainfall is in general sufficiently frequent to maintain the grazings in good condition; the summer is hot and the winter cold, but there are no extremes of temperature, and the State possesses very good water course systems. Four stock-raising zones are distinguished in this State. The frontier region has a climate and herbage closely approximating to those of Uruguay, and here the best beef

*"The Triangle" or "the Mineiro Triangle" is the name commonly given to the tract of land situated between the rivers Grande and Paranahyba in the western part of the State of Minas Gerais.

BRAZIL (showing towns etc., mentioned in text).

cattle in Brazil are raised, namely (in order of numbers kept), Herefords, Durham Shorthorns, Polled Angus, and Devons. The Serra or upland zone is an important pastoral region, having sheltered hill grazings with excellent water systems. Here the Zebu is dominant, followed by Charolais (introduced in 1903), Devons and Herefords. The central zone has a hot climate, low-lying campos and poor herbage: its cattle consist of Zebus and Creole stock, some Devons and a few Herefords. In the north-eastern part of the State the Creole cattle are raised on a large scale.

Santa Catarina and **Parana** have conditions resembling to a certain extent those of some regions of Rio Grande do Sul.

Although the geological situation of the central States—São Paulo, Mato Grosso, Goyaz and Minas Gerais—is good and resembles that of the southern States, their geographical position entails different climatic conditions.

For a description of the **State of São Paulo,** Dr. P. de Lima Corrêa (**3**) is quoted. " In São Paulo the natural campos, consisting of herbage deficient in botanical components and poor in chemical composition, are of very ordinary value, being for this reason replaced by artificial leys sown down in land that was originally forest. In these leys *Melinis minutiflora, Hyparrhenia rufa, Panicum maximum* and its variety *gongylodes, Chloris gayana* and *Cynodon dactylon* provide satisfying and wholesome feed for the better class stock."

He continues : " If for the better type of cattle the aid of supplementary rations is necessary, for the ordinary store cattle, the product of local farming and of Indian blood, grazing is sufficient and the only method of feeding that is compatible with the economic conditions under which animals are reared for the meat market.

" The grazings devoted to this purpose constitute the best that we possess, their value for fattening being equal to the best in existence. The rapidity with which thin cattle that have come from long distances reach the chilled beef stage surprises even experienced foreign graziers, accustomed to such mysteries in the more renowned stock-rearing regions. Whether it be in the tracts of red earth on the left banks of the rivers Pardo and Grande, whether on the arenaceous soils of the rivers Turvo, Jacare, Parana, and Tiete and the mixtures of volcanic efflorescences with the original sand deposits ; there is an extraordinary degree of fertility in all this land, which covers an area of over 50,000 sq. kilometres, a small part consisting of grasslands and a large proportion of forest, beginning in Barretos, Colina, Olympia, Itapolis, Novo Horizonte, Rio Preto and Monte Aprazivel, passing through Araçatuba and terminating at Anastacio and President Prudente—São Paulo possesses, in the tracts belonging to the Jurassic and more frequently to the Cretaceous and Triassic systems, one of the most propitious regions for the rearing and, above all, for the fattening of cattle."*

Mato Grosso is a natural prolongation of São Paulo from the banks of the river Parana. It has good water courses, and extensive campos covered with splendid natural herbage. Its stock-raising zone extends from the banks of the Parana to the sources of the Paraguay.

The State of Mato Grosso—although its name, " Great Forest," implies the contrary—is covered for approximately three quarters of its area by campos† and cerrados†† (campos with tree or shrub growth), the rest being occupied by wood and marsh.

" The Amazonian forests extend to a little below the 12th latitude south and follow the slope of the Chapadão [plateau] by the valley of the river Guaporé, passing then by the Parecis, darkening the sources of the Paraguay and its principal tributaries. In all the rest of the State, however, the forests are restricted to the banks of the rivers and ravines and to some slopes, and are then interrupted by campos. In Mato Grosso we thus find the same plant formations as those observed in parts of the States of São Paulo, Minas Gerais and Goyaz." (F. C. Hoehne (**4**).)

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*For cattle farming in São Paulo see also Reveilleau, *Herb. Abstr.* 9. Abs. 824. 1939.

†" The campos of Brazil . . . . do not consist of a uniform formation spread over a wide area, but of a richly differentiated, undulating park-like country, in which different forms of woodland and grassland partake, although the latter preponderates." A. F. W. Schimper. Plant-geography upon a physiological basis. Oxford, 1903. p. 373.

††A cerrado is a campo or grass prairie in which trees or shrubs of low, stunted habit, with thick bark and well-developed roots, are found, sometimes in such close formation as to impede progress, sometimes widely spaced. There is no cactus.

In the opinion of Hoehne, it is not admissible to identify the Mato Grosso cerrados or tree-grown campos with the caatingas* or thorn-woodland, for in Mato Grosso the rainy season lasts from six to seven months of the year, which provides more moisture for the cerrados than that available for the caatingas of north-east Brazil, where the rainy season lasts only four to five months.

Of the Great Swamp the highest parts, together with the cerrados and the hydrophilous forests, are of interest for stock-raising. During the floods the higher parts are invaded by the water, which is at times as much as two to three metres deep. When this water has drained off, grasses and other herbage plants germinate, whereby these localities are transformed into excellent grazings of great nutritive value. On account of the periodic flooding there are neither warble flies nor ticks there. These grazings are used during the dry period, after flooding.

Of the herbage plants found in the State, grasses take the first place and legumes the second. These two groups of plants are, from the nutritional aspect, complementary. As is known, the grasses are characterized by their large percentage of carbohydrates and their very low content of proteins, while the legumes, on the contrary, are rich in proteins and poor in carbohydrates.

Species of the genus *Panicum* constitute the most important of the grasses; then follow representatives of the genus *Paspalum* and various species of *Eragrostis*, *Andropogon*, *Chloris*, *Manisurus* and *Sporobolus*. In the Chapada [plateau] there are wide areas in which *Tristachya chrysothrys*, *T. leiostachya*, etc., are dominant.

Of the legumes, *Meibomia* species—perfect substitutes for the foreign lucerne—are found in abundance, namely, *M. pachyrrhiza*, *M. platycarpa*, *M. aspera*, etc. There are also found representatives of the genera *Crotalaria*, *Stylosanthes*, etc.

The **State of Goyaz** is divided physiographically into five zones, according to official returns, as follows: I. North; comprising 372,614 sq. km.: II. Plateau; 64,114 sq. km.: III. Centre; with an area of 80,031 sq. km.: IV. South; 59,559 sq. km.: and V. South-east; 83,875 sq. km.

The plant cover of these zones is distributed as follows: I. Forest (251,509 sq. km.); II. Cerrados (248,336 sq. km.); III. Caatingas (68,783 sq. km.); IV. Campos (80,177 sq. km.); V. Flooded campos (2,951 sq. km.); and VI. Swamp (8,437 sq. km.).

The State of Goyaz, therefore, possesses very vast campos covered with natural herbage, in which are dominant native herbage such as *Hyparrhenia rufa*, *Centrosema plumierii* [a legume], *Melinis minutiflora*, *Paspalum fasciculatum*, *Chaetochloa purpurascens*, *Heteropogon villosus* with its varieties *genuinus*, *dactyloides* and *apogynus*, and *Paratheria prostrata* Griseb. Water relations are satisfactory. The best cattle-raising zone is situated in the south-eastern part of the State, however, in closer contact with the Triangle region of Minas Gerais.

The **State of Minas Gerais** is composed of land without any uniformity, whether considered from the physical point of view or from that of topography and altitude. To this diversity must be added that of climates dissimilar in regard to temperature and rainfall alike.

Minas Gerais comprises the following stock-raising regions, arranged in descending order of their bovine population: south, Triangle, west, Mata, centre, north-east, north, north-west and east.

*The Brazilian caatingas are light-forests which "exhibit thorny bushes, chiefly formed of Mimoseae, among which there rise more or less numerous trees, including the strange 'barrigudos' and columnar Cactaceae. Thin lianes climb among the bushes; epiphytes are absent or are extremely scarce. The herbaceous vegetation is limited to prickly Bromeliaceae . . . . The caatingas . . . lose their leaves during the dry season and break out into leaf again only after persistent rain has set in with the wet season." A. F. W. Schimper. *op. cit.* p. 360, and C. F. P. von Martius. Die Physiognomie des Pflanzenreichs in Brasilien. Munich, 1824. pp. 16-7, quoted by Schimper.

The rearing of beef cattle is carried out preferably in the Triangle, or tract of land situated between the rivers Grande and Paranahyba. This area is considered to be one of the most fertile parts of Brazil.

The Triangle is characterized by the grazings of its upland plateau, the herbage of which consists of common, indigenous species such as *Melinis minutiflora*, *Hyparrhenia rufa*, *Tricholaena rosea*, *Echinochloa polystachya* and *Helopus polystachys*. The mean altitude of the plateau is from 550 to 700 metres, and its geological formation is very varied. This diversity of soils has as a consequence a great diversity in the natural herbage, from hard and unpalatable to tender. The water courses are limpid, shallow and flowing.

The climate of this region is more hot than temperate, on account of its geographic position and altitude. In the centre and in the north, that is to say, in the municipalities of Uberlandia, Araguari and Ituiutaba, the average maximum temperature ranges from 20 to 25° C., and the minimum from 15 to 20° C. In south Frutal, Sacramento and Conquista the average maxima range from 15 to 20° C. and the minima from 10 to 15° C. Strong insolation, little fog, and rainfall ranging from 1,500 to 1,700 mm. are further characteristics.

The Triangle is, in addition, almost exempt from ticks and warble flies, one of the reasons why the cattle from that region are clean and have good hides.

In general it may be said that, as well as in the Triangle, beef cattle are raised in the north, north-east and north-western parts of the State. In the west and south the tendency is to keep dual-purpose cows, for milk and meat. In Tres Corações, in the southern part of the State, there is held one of the most famous and ancient cattle fairs of central Brazil, to which are brought great herds from the breeding grounds of the region, from the Triangle, Goyaz and even from Mato Grosso. The commercial interchange of cattle between the south of Minas Gerais and the other parts of the State and even other States is thus active.

In Minas Gerais, as in the other States already described in this article, herbage is green and abundant in the rainy, hot season, drying up, however, and almost disappearing in the dry and cold season. The cattle thus fatten well in the former season, and become lean in the second. Another inconvenience of the great majority of the Minas Gerais grazings is that of ticks, which make the animals thin by sucking large quantities of blood, thus retarding fattening as well as reducing the value of the hides and diminishing milk production.

The **State of Bahia** has two main zones for the fattening and rearing of beef cattle, situated in different parts of its territory and known respectively under the names of the most important towns in each zone, Conquista and Mundo Novo.

The Conquista zone, situated in south-eastern Bahia, is considered to have an important future in the rearing of beef cattle, in spite of its relatively small size. It includes the municipalities of Conquista, Itambé, Encruzilhada, Poções and part of Canavieiras, and consists partly of forest and partly of caatingas, and, consequently, also of liane forest, transitional between the two other forms of vegetation. Its area exceeds 30,000 sq. kms., and contains the basin of the river Pardo and its tributaries the Palmeiras, the Catolé, the Verruga, the Mangerona, the Colonia, the Maiaquinique, etc. The land, formerly under forest, has tracts of clay soil covered with grasses and legumes as yet little studied. Guinea grass (*Panicum maximum*), which is extraordinarily productive, is dominant. The climate is good, with a mean annual temperature of 23° C. Rainfall is abundant, ranging from 1,500 to 2,000 mm. per year.

The south-east of Bahia is said by many agricultural experts to be equal to the region of Barretos, Colina, Olympia and Aracatuba in the State of São Paulo. It is believed that Bahia—through this region—is likely in the near future to occupy a more important position in the national stock-raising industry.

The Mundo Novo zone is formed by the municipalities of Mundo Novo, Rui Barbosa, Baixa Grande, Monte Alegre, Camisão, Capivari and Itaberaba. The river Paraguassu and its tributary the Jacuipe flow through this area. The land of this region also has tracts of clay soil formerly covered by forest, where extend grasslands dominated by *Panicum maximum*. Although much less favoured than the Conquista zone in regard to climate and permanent water-courses, it does not fail to lend itself to stock-raising, for the contour of the land—hills, valleys, and river basins—facilitates the storage of water in reservoirs and tanks.

Mundo Novo, like neighbouring municipalities, has, unfortunately, for some years been wasted by droughts that transform its grasslands into veritable deserts and decimate its herds.

The principal trade in cattle in Bahia, and perhaps in the whole of the country, takes place in the city of Feira de Sant'Ana, to which the great majority of the herds from the ranches are taken. From this market beasts are sent to supply the meat markets of the capital and of neighbouring localities. There is a cattle fair at Bom Fim also, but it is of secondary importance.

There is no intensive stock-raising in the north-east of Brazil on account of the unfavourable climatic conditions. In spite of these conditions, however, it is possible to develop stock-raising there by the production of supplementary fodder for the long periods of drought and by resorting, for example, to the introduction of the zebu, product of a similar environment and, therefore, anatomically and physiologically adapted to the climatic conditions and scarcity of fodder.

Few cattle are kept in the north of Brazil, consisting of the **States of Amazonas and Para** and the **Territory of the Acre,** all richly endowed with flora of good forage value.

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EROSION AND PASTORAL RESEARCH IN KENYA

[Reviewer: R. O. Whyte]

It has already been noted in this journal that Dr. I. B. Pole Evans, Chief, Division of Plant Industry, Department of Agriculture, Pretoria, South Africa, has reported on the results of a visit to Kenya from May to August, 1938 ("Report on a visit to Kenya," Govt. Printer, Nairobi, 1939, pp. 36. pls. map). This visit was made at the request of the Government of Kenya, with the object of giving Government officers there some advice in connexion with measures proposed to deal with soil erosion and the regeneration of grasslands. The journey to Kenya from South Africa was made by road, in order that the opportunity might be taken to study the grasslands en route through Southern Rhodesia, Mozambique, Nyasaland, Northern Rhodesia and Tanganyika.

In his report Dr. Pole Evans first states the following four facts :

The greater part of Kenya is desert country
Semi-arid grassland forms a wide belt of natural vegetation beyond the desert zone
Parkland and tall grass country occupies the south-western portion and forms an irregular belt around the Highlands
Natural forest occurs mainly in the highland country.

Erosion is general and serious in the first three zones and particularly in the first two. The attempts which have been made to develop agriculture, particularly the production of cash crops for export, are vigorously criticized, and it is stated that only through an intensive programme of pasture research can the land of Kenya be saved. Recommendations are made for complete resting and reconditioning of not less than 50,000 acres in the most badly eroded parts of the native reserves. It is suggested that each such area should contain a pasture research station, these stations to be grouped in an active and powerful Department of Pastoral Research—"a department which will not only save the semi-arid and arid regions, but will also in course of time build up pastoral industries on the magnificent natural pastures of Kenya's moister regions."

It is stated that Kenya has all the essentials necessary for building up a successful livestock industry,

(a) an area for extensive ranching practice
(b) an area suitable for intensive systems of pasturage and dairying
(c) a crop production area for the fattening of stock.

A suggestion which will not be so readily accepted by forestry and water conservation specialists is made in connexion with the grasslands of the Highlands, which are characterized by the presence and frequent dominance of the perennial and evergreen stoloniferous kikuyu grass (*Pennisetum clandestinum*). Pastures thirty years old show no signs of deterioration or decline in yield. "Kenya's future prosperity lies in the full development and greater use of this perennial evergreen pasture, and the day is not far distant when Kenya will be compelled to follow New Zealand's example and convert what is at present forest reserve of very doubtful value to the State into the finest natural pastures of the Empire." The author hopes that this will be carried out on scientific lines, without the destruction characteristic of the transformation of New Zealand bush country into grassland. Striking examples were noted of homesteads where full advantage had been taken on the one hand of the natural forest to beautify the surroundings, and on the other of the valuable pasture land for dairying, and the extension of this practice is recommended.

SCANDINAVIAN LITERATURE

CULTIVATION IN THE SETER (MOUNTAIN PASTURE) REGIONS OF NORWAY. BETTER UTILIZATION OF THE "FIRST FLOOR" OF MOUNTAIN DISTRICTS

[Reviewer: R. Peter Jones]

This is a review* of a report by the Director of the Nord-Gudbrandsdal School of Agriculture.

It was mainly at Klonessetra, the seter of the School of Agriculture which lies 900 metres above sea-level, that the experiments described in the report were conducted.

On the seter fold comparatively short-duration leys were used, 4 to 5 years, and it was found that the normal seeds mixture, two-thirds timothy—one-third red clover gave the best results. In practice very frequently a small amount of alsike clover is added to the mixture, and, when Norwegian seed can be procured, also a little red fescue, smooth-stalked meadow grass and meadow fescue. The use of comparatively heavy seed rates is recommended; 4—5 kg. per decar of the mixture are not too much here.

For such short-duration leys as those used here it is seen that timothy and red clover play a predominant part among the meadow plants, both on upland ground and on ground of a boggy character. It is surprising that red clover, which is never particularly persistent in leys even in the lowlands, in this seter fold maintained itself up to and including the fourth year of the ley. Certainly only during the first two years did the clover increase the yield to an appreciable degree. The Director points out that weather conditions (good covering of snow) and soil reaction (weakly acid to alkaline) are favourable for clover in these regions. It is emphasized that grazing on the seter fold must not be too hard during the autumn and spring if the clover is to persist.

The report also deals with manurial and liming experiments, investigations on nutritive value of seter hay, calculations of profitableness, the addition of concentrates during the grazing period of the seter, and a number of other questions regarding seter management.

As it is often difficult to obtain adequate and good pasture in the spring and autumn in the seter regions, in 1924 at Klonessetra 23 decar of bog were enclosed with the object of conducting experiments with cultivated pasture. Various methods of surface cultivation were tested, and it was found that the method consisting of clearing scrub, levelling mounds and sowing seed was the most advantageous one there. This method has since been used in the cultivation of this pasture area. The seeds mixture was composed mainly of timothy, with in addition small amounts of white clover, meadow foxtail, smooth-stalked meadow grass, *Agrostis*, red clover and meadow fescue. The rate of seeding was approximately 5 kg. per decar. The best seed obtainable should be used.

To obtain a good yield, liberal manuring is essential.

*Dyrking i setertraktene. Bedre utnyttelse av fjellbygdenes "annen etasje." S. Skaare. (Cultivation in the seter (mountain pasture) regions of Norway. Better utilization of the "first floor" of mountain districts. *Norsk Landbruk* 5. 428-30. 1939.

SWEDISH SEED GROWERS' ASSOCIATION

[Reviewer: R. Peter Jones]

The Scanian Seed Growers' Association has as in previous years conducted extensive experimental work to determine, in particular, the cultivation value of a large number of strains of fodder root crops and red clover. (Fröodlareföreningarnas berättelser för ar 1938. (Reports of the Seed Growers' Associations for the year 1938.) *Svensk Frötidning*. 8. 69-73. 1939.) Experiments were also conducted with lucerne, while manurial trials in seed plots were also carried out.

The extent of seed production during the past year was considerable, and the seed produced was of good quality.

For many years Scanian seed production has in the main comprised seeds of roots and various meadow grasses. In recent years, however, seed production of grassland legumes and especially of red clover and white clover has increased. Although seed production of red clover is still not practised on a scale large enough to meet the needs of the province itself, it is conducted in a rational way and on seed plots. During 1937 and 1938 prices of red clover seed were too low to induce growers to extend their seed-production areas.

Also during 1938 a considerable quantity of foreign red clover seed was imported. The experimental work of the Association has shown that Scanian medium-late red clover strains give a higher yield than the early clover assuming that the first cut of the former is taken at a relatively early stage or before the beginning of flowering. A reduction in the use of early foreign red clover and an increase in the use of red clover seed of medium-late Swedish types can, therefore, be recommended.

Plant diseases and noxious insects have caused certain losses to seed growers. Injuries to swedes and turnips have been relatively slight. On the other hand, seed plots of fodder beet and sugar beet have suffered greatly from Aphis attack; spraying with nicotine has, however, had a very beneficial effect.

The following sections give brief details of the activities of Seed Growers' Associations in the various provinces.

Östergötland

During the past year the extent of seed production has been approximately the same as in the previous year. Possibly the red clover and timothy areas have been somewhat smaller than in 1937, but the alsike areas, on the other hand, have been slightly larger.

The development of the leys at the time of cutting of the hay was satisfactory and the stand on the marked-off seed areas had made good growth. Pollination and seed setting took place under favourable conditions, but immediately afterwards a long warm, dry period set in, which had an unfavourable effect on the supply of nutriment to the seed, which was poorly developed and frequently ripened prematurely. When harvested, the yield from the seed leys was for many growers disappointing.

The low yield of red clover was in part due to attack by the clover weevil. Attacks by this parasite have increased considerably in recent years, and in certain districts have rendered seed production of red clover impossible. During the past summer the State Institute for Plant Protection has investigated the severe attacks in Östergötland and it is hoped that positive measures of control will soon result.

Of the clovers, alsike appears to have suffered most from the dry period. The yield from the alsike leys has therefore, particularly in the lowland areas, often been strikingly low. On the other hand, the timothy seed plots have given approximately normal yields.

Quality has, broadly speaking, been good. Certainly some red clover seed owing to rain was brown in colour, but, on the whole, the quality of this species too was satisfactory. Alsike clover seed is of good quality and colour, although in some cases the seed is small in size. Timothy seed is well developed, but was slightly damaged by rain, for which reason it is dull in colour.

The price of red clover and timothy seed has improved appreciably during the autumn. On the contrary, the price of alsike seed at the turn of the year was exceedingly poor. The usual export of alsike seed did not take place this year.

It should, however, be remarked that the seed plots of alsike in Östergötland are now so extensive that the cultivation is much in excess of the country's requirements of this species of seed. The price is, therefore, dependent on the condition of the world market.

Jönköping

During 1938, the number of members was 78.

As regards experimental work it is reported that observation plots with red clover were put down at three centres.

The observation plots with red clover put down the previous year to test the resistance of different strains to clover stem rot showed that none of the strains proved appreciably resistant to the disease.

Concerning the work at the seed cleaning depots it may be mentioned that the weight of clover pods hulled was 88,530 kg. and the amount of seed obtained was 17,380 kg.

Örebro

By means of lectures and pamphlets an effort has been made to convey to growers information concerning the correct treatment of the crop in threshing, hulling and cleaning. Particular attention has been paid to the question of weeds.

For a number of years the Assocation has striven for the best possible cultivation material of Swedish late clover. With this object in view seed of two strains well suited to the province has been procured and distributed to 70 growers.

The Association's cleaning depot in Örebro has been at work during the greater part of the year, and 1,158 dt. seed and 1,817 dt. grain have been cleaned there.

Uppsala

The Association has firstly, concerned itself with the cleaning of seed and grain in Uppsala and secondly, carried out certain measures supported by the State and the agricultural society for the furthering of seed production in the province of Uppsala. The last-mentioned branch of work has comprised: germination tests and purity analyses of seed of meadow plants cleaned at the Society's seed cleaning depot in Uppsala; comparative trials with various strains of red clover (in collaboration with the Ultuna Branch Station of the Swedish Seed Association); lectures, publication of articles, and organization of seed exhibitions, etc.

It is recorded that during the year 34,384 kg. seed and 74,616 kg. peas and other grain were cleaned at the seed cleaning depot.

PRODUCTION AND HARVESTING OF TIMOTHY SEED

[Reviewer: R. Peter Jones]

In 1925 in connexion with the production of timothy seed in Norway, manurial and time of cutting experiments were initiated, and in 1931 manurial and harvesting experiments. They were continued until 1936. The preliminary results of the one manurial experiment and time of cutting experiment were published in 1932 (Tidsskrift for det norske Landbruk, 39. 57-80. 1932). The results reported in the present paper, and summarized below, are based on fields situated at one centre in the case of the manurial and time of cutting experiments and at four different centres for the harvesting experiments.

Manurial Experiments

Potash and phosphoric acid manure alone have, practically speaking, given the same yield of timothy seed as no manure. On the other hand, such manuring has encouraged the clover, and the yields of fodder have also increased slightly, which may possibly be attributed to the larger content of clover.

All-sided manuring with 30 kg. S. + 15 kg. K. + 20 kg. N. per decar has increased the yields of both seed and fodder considerably. 50 kg. S. and 25 kg. K with 20 kg. N. per decar have raised the yields still further, and 40 kg. N. together with 30 kg. S. and 15 kg. K. per decar have brought about a considerable increase both in seed and seed hay. N. alone has had a great effect on both seed and seed hay.

The most economic manuring in these experiments has been manuring IV—30 kg. S + 15 kg. K. + 40 kg. N. per decar with a margin of profit of 12.85 kr., while S and K. alone have given a deficit.

Manuring with Incremental Amounts of Nitrogen

Under the conditions prevailing here the experiments show that seed crops and fodder crops of timothy rise very markedly when to a basal manuring of potash and phosphoric acid 30 kg. and 60 kg. calcium nitrate per decar are added. The increase is greatest per cent from no calcium nitrate to 30 kg. When the amount of calcium nitrate is raised from 60 to 90 kg. per decar the results are uncertain, as three fields gave less seed and three fields gave more seed and on the average only 4 per cent larger crop. The same applied also to the fodder yields with an increase of 4 per cent, but here only in one year was the yield of fodder less with the largest amount of calcium nitrate.

As to profitableness with calcium nitrate manuring, it is seen that manuring C—60 kg. per decar, has given the largest return, 18.18 kr. per decar. Next comes manuring D—90 kg., with 16.51 kr. per decar, and finally B—30 kg., with 15.37 kr. per decar.

It is seen that for seed production of timothy large amounts of saltpetre manure can be used and that an amount of up to 60 kg. calcium nitrate per decar has increased both the size of the yield and the profitableness of the crop. By increasing the amount of calcium nitrate to 90 kg. per decar, the average yield has been raised somewhat, but unequally from year to year and the profitableness has been less.

°Forsøksresultater ved avl og berging av timoteifrø. O. Lier. [Results of experiments in the production and harvesting of timothy seed.] *Tidsskrift for det norske Landbruk.* 46. 197-235. 1939.

Time of Cutting

A ripening period of about 24 days after flowering, when the seed is still firmly attached, is too short. If cutting is carried out at this time the seed crops will be comparatively light.

The proper time of cutting appears to be before the seed has begun to loosen at the top of the spike, but can easily be rubbed out. This has, on the average, occurred about 32 days after flowering.

A postponement of cutting for a further eight days has not appreciably increased the seed yields or the weight of 1,000 seeds, and there does not appear to be any reason for waiting so long before cutting.

The fodder yields (the seed hay) increase to some extent if the time of cutting is delayed, but this increase is not regular in the different years. Whether the value of the seed hay rises to the same extent is more doubtful.

Threshing

Under favourable drying conditions and where scythes or mowing machines with hand delivery attachments are used in cutting, the single sheaf stook is a sufficiently safe method of harvesting and can be recommended. This method is labour-saving and cheap. The crop should not contain too much clover. The places where the use of this method of harvesting can be recommended are Østlandet, the greater part of Sørlandet and places with similar drying conditions.

If the self-binder is used in cutting, the four-sheaf stook with loose tie around the top is to be recommended in the places mentioned in No. 1 above.

The four-sheaf stook can possibly also be used with advantage in places with somewhat more unfavourable drying conditions than those referred to above.

Under unfavourable drying conditions sloping frames, poles in a circle, and, under the most unfavourable conditions, ridge frames can be recommended.

ANNUAL REPORTS

AFRICA

Sudan, Department of Agriculture and Forests, 1937.

At the Gezira Research Farm suitable types of various introduced leguminous crops have been selected for further trial. Certain strains of *Glycine* were promising. Poor germination and subsequent loss of *Mucuna* due to attack by *Macrophomina phaseoli* have resulted in the crop being regarded as unsuitable for Gezira.

The potentialities of the extreme south of the Sudan as a field for the development of a range of tropical crops, either introduced or developed from indigenous sources, are being explored. An ecological survey forms the basis of the study and preliminary stages of plant introduction work are developed at Kagelu. The plant communities so far observed include three types of grass-woodland, two of grassland, and two of grass swamps. Only the first and last are of great extent and of any considerable economic importance.

Experiments on the improvement of soil fertility include the removal of sodium by growing *Atriplex* sp. *A. Muelleri* produces the best growth and extracts marked quantities of sodium from the soil.

Sierra Leone, Department of Agriculture, 1937.

Rokupr Experimental Rice Station. The fertility of the rice nurseries is largely maintained by growing leguminous crops, chiefly *Pueraria*, *Centrosema*, *Vigna* and *Crotalaria*.

Njala Agricultural Station. The chief experiments are concerned with the maintenance of soil fertility by growing crops which afford food for man or fodder for animals. Experiments with *Cajanus indicus* were started in 1936. *Centrosema pubescens* has also been sown on two acres and a good cover established. The crop is grazed readily by sheep and a folding trial was started in 1938. The relative merits of species of *Stizolobium*, *Canavalia*, *Pueraria*, *Calopogonium*, *Centrosema*, *Tephrosia* and *Cajanus* for green manure are being tested.

A comparative yield trial has been devised to determine the effect of planting date and incidence of virus disease on yield of *Arachis* sp. Results show that early planting does not reduce the incidence of virus disease, yield is not affected significantly by early or late planting, and wider spacing gives sufficiently greater yield per plant to compensate for a decrease in plant numbers.

The report of the Plant Pathologist includes new host plants for certain fungi and new fungous species not previously recorded in Sierra Leone.

Gambia Colony, Department of Agriculture, 1938.

Cattle are found in all districts and swampy ground provides good succulent grazing when the flood waters recede. This, together with browsing on young shrub and tree growth, provides feed throughout the most difficult period of the year. Conservation of fodder is not practised for cattle, but stock are allowed to feed on crop residues after corn has been harvested and the groundnuts threshed. *Striga* sp. is a pest on all Guinea corn farms.

Gold Coast Colony, Department of Agriculture, 1937.

Northern Territories. Dry farming methods have been intensified at the Tamale Station. Two unit-holdings are maintained; one consists of 10 acres divided into eight blocks of equal size and the other of eight one-acre fields separated by strips of fallow, the object being to check erosion and provide some grazing. The rotations include millet, maize, Guinea corn, Bengal beans, groundnuts, etc., in addition to cotton, cassava and Acha-grass (?) fodder. The remaining work of the Station includes crop-rotation trials, comparison of green manures, pasture-grass trials, and selection of resistant strains of groundnut.

Nigeria, Department of Agriculture, 1937.

Uba canes, wild canes and sweet potatoes are fodders obtained from the West Indies which are being multiplied, and tests under a variety of conditions are to be started. *Pennisetum purpureum*, *Panicum maximum*, gamba grass and native sugar canes are being studied on most farms. A small plot of gamba at Maigana produced 8,700 lb. green fodder during the year. The best method of producing and utilizing *Cajanus indicus* is being studied. This crop survived the dry season on the poor sandy soils at Birnin Kebbi. Strains from India are being multiplied for experimental work.

Although erosion in Nigeria is not a serious problem compared with other countries, the effect of wind erosion in the Northern Provinces is being studied on a farm at Daura. Anti-erosion measures include leaving weeds in the soil during the dry season, strip cropping, planting belts of pigeon peas and the construction of wind breaks. At Samaru and Shika also, badly-eroded areas are being protected by means of broad-base terraces.

Uganda Protectorate, Department of Agriculture, 1937-38.

In the Chemical Section, field studies relating to erosion and regeneration of worn-out land are carried out. The layout of an erosion experiment has been described by Martin and Biggs (*E. Afr. Agric. J.* 2. 371-8. 1937). This year the experiment has been put down to cotton after carrying a crop of *Eleusine coracana*. Yields obtained after specific manurial treatments are recorded.

The Kampala Regeneration Experiment was started in 1933. The area was divided into four equal parts, two being planted with *Pennisetum purpureum* and two with *Centrosema pubescens*. The former gave an excellent cover within six months, while *Centrosema* grew slowly and had to be weeded several times before a complete stand was obtained. Moisture and nitrate determinations were made during the cover crop growth. Nitrate was higher under the legume than under grass, whilst moisture range under grass was greater than that under the legume, but differences were not statistically significant. There is evidence, however, of the regenerative effect of both covers and of the fact that Elephant grass is superior to the leguminous cover.

The Report of the Senior Botanist, Bukalasa, contains information regarding *Glycine* yields. Higher yields are expected as seed becomes acclimatized and soils become infected with the nodule-forming organism. Of the varieties Barberton Y 1, Laredo and Serere, the last, selected by Hosking in Trinidad, appears to be suitable for forage. Varietal trials are also in progress with *Arachis*, *Sorghum* and *Pisum* among other crops at the different centres.

The report from the Botanic Gardens, Entebbe, records that lawns of *Cynodon dactylon* have become overgrown with coarser grasses and weeds. Areas replanted with *Brachiaria decumbens* and *C. dactylon* have developed a good sward.

The Agricultural Officer, Masindi, describes the experimental work of the Northern Province. The main object of work on pasture plants at Ngetta is to evolve a good temporary ley suitable from the point of view of grazing capacity and soil regeneration for the three-year resting period which occurs in the local rotation. This involves study of (1) seed viability of the various pasture plants under local conditions and of methods of seed collecting ; (2) methods and time of sowing and of establishment ; (3) seeds mixtures, and (4) grazing, including the residual value of various grasses when grazed and ungrazed at the end of a three-year period. Results obtained to date show that one ox per acre can be supported throughout the year and during rainy months the carrying capacity of the pastures may be 2.5 oxen per acre. There is indication that close grazing encourages the spread of *Cynodon dactylon* at the expense of other grasses. Weeding the pastures at initial stages is disadvantageous and if pastures are left ungrazed for 6 or 7 months after sowing, a closer cover is obtained. *Chloris gayana, Hyparrhenia filipendula* and *Brachiara decumbens* are the most promising of the grasses tested. *H. filipendula*, however, should not be grazed closely. Under Ngetta conditions *Pennisetum polystachyon* is useful in a seeds mixture because of the quick growth and good cover it affords in early stages of the pasture. It dies out in the second year, however.

Kenya Colony and Protectorate, Department of Agriculture. Nairobi, 1939.

Forage crop experiments reported include the following : the method of preparing sprouted grain has been successful and the grain is now recommended as a cheap, succulent feed under Kenya conditions ; trials on the preparation of young, dried grass show that this process can have only limited application in Kenya ; tests with silage crops have demonstrated the value of molasses for ensiling material such as vetches and *Pennisetum purpureum* ; the trials at Njoro and Rongai show that a high yield of green feed can be obtained from *Pennisetum purpureum*, and that kale, Hubam clover (? *Melilotus alba* var. *annualis*) and vetches are also valuable. Promising results have been obtained with *Vigna* sp., spineless cactus, and Wintersome (? maize variety).

Pasture research has involved study of legumes suitable for grass mixtures in areas of intermediate climatic conditions. Former reports recorded that *Lespedeza* spp. and *Trigonella foenum-graecum* do not survive in mixture with *Chloris gayana* and *Bothriochloa insculpta*. *Astragalus venosus* shows promise as a pasture legume, although *Medicago* and possibly *Indigofera tettensis* are the most useful types. The merits of a Giant *Cynodon* species (received from Uganda in 1934) for a considerable range of climatic and soil conditions are noted. Particular attention is being paid to the study of ecotypes of *Chloris gayana, Pennisetum clandestinum* and *Cynodon* spp. Experimental work at Kabete is developed with a view to more intensive methods of farming wherever the rainfall is sufficient. An experiment in controlled grazing has been started also on the Yatta Plain, an area of low rainfall.

Among the grass trials reported it has been shown that certain mixtures of English and Australian species are suitable for short-term leys in the high-altitude areas. In the Njoro pasture plant trials, indigenous species of *Glycine* from Ulu and *Tephrosia* from Songhor are promising. Sheep's burnet (*Poterium sanguisorba*) appears to have value as a constituent of a pasture mixture for highland areas.

Seed farms are established in the three agricultural provinces, namely, Nyanza, Coast and Central. Improved strains and varieties of useful crops are produced for issue to natives.

British Somaliland, Veterinary and Agricultural Department, 1938.

A general review of the grazing and soil-erosion situation is in progress. Although erosion is in an advanced state, closing areas to grazing in various parts of the plateau region has produced remarkable results. The expansion of this scheme to cover the whole of the Protectorate is advocated. Planting indigenous grasses or sowing seed is too costly for widespread application, but is advisable for places such as Burao.

In connexion with pasture revegetation, the Gillette collection of plants has been catalogued. Few grasses are represented. A collection of plants is being made which will form a permanent record of Somaliland vegetation.

Among arable crops are: maize, Katengu sorghum, peas, *Phaseolus mungo*, *Arachis* sp., melon (drought-resistant plants have been introduced from the Sudan where they are used as the sole source of water, and seeds have proved nutritious); trials with *Agropyron cristatum* and *Trifolium* spp. have given negative results.

Zanzibar Protectorate, Department of Agriculture, 1938.

Popondo beans (*Phaseolus* sp.) are cultivated as a food and cover crop. A species of *Vigna* imported from Tanganyika Territory appears to produce better yields than local types. Of the imported varieties of *Glycine hispida* only one, Barberton Yellow, has been tested. Growth is poor and there is no nodule formation. A strain of *Rhizobium* has been introduced into the soil. Preliminary trials with Mauritius peas have been successful and trials with West Indian and Punjab varieties of *Cajanus indicus* are in progress.

Tanganyika Territory, Department of Veterinary Science and Animal Husbandry, 1937.

It has been emphasized that rotational grazing schemes play a valuable part in the solution of erosion problems (see Staples, *Herb. Abstr.* 7. 172. 1937). Schemes have been formulated by which grazing is regulated under the two forms of land tenure, individual and communal.

Pasture development is in progress at demonstration farms, notably that at Dodoma, where evidence has been obtained of the inadequacy of good star grass (*Cynodon plectostachyum*) pasture for maintaining stock.

Information is also available regarding the nutritive value of cassava roots, cowpea seeds, legume hays, of grass when fed green, as silage or as hay, and of rice by-products for ruminants.

Continuing the work reported earlier (Staples, *Herb. Abstr.* 7. 154. 1937), determinations have been made of percolation rate of rainfall in semi-arid East Africa, under different types of vegetation. Work includes also study of the effect of fire on mountain grassland, the effects of different intensities of grazing on a mountain grassland type and observations made at Mpwapwa of indigenous and introduced grasses (*Panicum maximum*, *Pennisetum purpureum* and *Bothriochloa insculpta*) with a view to determining their relative value for pasture or fodder production in the ecological zone which at present comprises the most important stock areas of the Territory. (See also Staples, *Herb. Abstr.* 7. 103-4 and 172. 1937.)

Among the general experimental farms, that of Morogoro maintains the dairy herd on edible canna, elephant grass, *Dolichos lablab* and sweet potato tops with some grazing. Other foodstuffs used as emergency rations are sugar cane, *Leucaena glauca* and banana stalks. Areas of eroded lands have been contoured and planted with Rhodes grass and star grass. It is hoped to graze all the farm pastures in rotation.

Amani, East African Agricultural Research Station, 1937.

The failure of grain crops on certain newly-cleared bush lands forms a subject of investigation on land cleared from *Acacia pallens—Combretum* sp.—*Panicum maximum* open savannah bush. The field experiment has been initiated at the Kingolwira Experiment Station near Morogoro and is designed to determine the soil changes that take place when virgin savannah is broken for annual crop cultivation.

South Africa, Department of Agriculture and Forestry, 1938.

The issue of *Farming in South Africa* 13. No. 153, for December, 1938, contains the Annual Report of the Secretary for Agriculture and Forestry in addition to annexure reports of the following Divisions :

(1) *Veterinary Services.* Research in pharmacology and toxicology includes the testing of plants for their toxicity, and nutritional studies include those of protein values of grass and other feeds, and the amount of grazing consumed by sheep under natural conditions.

(2) *Plant Industry.* The work of the grass Breeding and Research Stations is recorded, certain details of which have been described in *Herb. Rev.* 7. 80-5. 1939. The Prinshof Grass Breeding Station conducts, among other research, investigation on seeds in which special attention is given to after-maturation and storage, because most of the South African indigenous grasses show delayed after-maturation resulting in poor germination of the majority of strains. In view of the results, which show the value of heat and sunlight for the improvement of germination, new studies have been started in which the value of various periods of pre-heating and pre-cooling for sunlight treatment, and the effect of various alternating periods of heat and cold, of heat and sunlight, of cold and sunlight and of various light wave lengths are compared. Tests are also included to study the effects of continuous exposure to heat and the influence of various periods of wetting and drying, of soaking and freezing, of soaking alone, and of mechanical and chemical treatment.

In regard to plant pests and diseases study is being made of the biological control of *Opuntia* spp., of the amount of damage done to grazing areas by harvester termites (*Hodotermes* spp.) and insect pests of stored seed (*Bruchus analis* on *Vigna* sp.).

(3) *Agricultural Education and Extension.* Problems specific to areas in which the institutes are located are investigated by the Schools of Agriculture and Experiment Stations at Cedara, Natal, Glen, O.F.S., Grootfontein, Middelburg, C.P., Potchefstroom, Transvaal, and Stellenbosch, Hope Province.

Basutoland, Department of Agriculture, 1937.

A complete ecological survey was undertaken during the year and recommendations have been made regarding pasture experiments. Initial clearing has involved the destruction of rodents by means of poisoned wheat. The experimental grass plots in which the introduction of suitable varieties is studied, indicate that *Poa inermis* (indigenous to Basutoland) and *Agrostis tenuis* are suitable for planting on contour banks, although of the introduced varieties *Pennisetum clandestinum* has so far proved most satisfactory in this respect. *Cynodon dactylon* is also a soil binder but is recommended only for adverse conditions in cultivated areas because of its inferior grazing qualities.

Multiplication plots have been established in all districts for determining the most suitable varieties of trees and grasses for erosion work. They are also utilized for the propagation of selected seed. All the plots, with the exception of those in the Teyateyaneng district, are under irrigation. Initial experimental work is carried out on the Maseru Experimental Plots and field trials of promising varieties are then

started. Trials with the following grasses are in progress: summer varieties—Dunn's finger, *Axonopus compressus*, *Setaria* sp., *Pennisetum clandestinum* and *Cynodon dactylon*; winter varieties—*Agropyron repens*, *Poa inermis*, *Holcus lanatus* and *Agrostis* spp.

Apart from the planted pasture areas there are cultivated areas in which *Medicago* and *Lolium* are under trial, the latter in the Mohale's Hoek district.

Rhodesia Agricultural Experiment Station and Plant Breeding Station, Hillside. 1936-7.

The Rhodesia Agricultural Journal, 35. 521-37. 1938, contains the annual report of the Agriculturist. Several farms in the Melsetter district are carrying out trials with winter grasses and legumes in co-operation with the Department. Red top, brown top, *Holcus lanatus*, *Dactylis* and New Zealand Tall fescue with New Zealand *Trifolium repens* have shown good promise, while *Poterium sanguisorba* established well and showed extraordinary drought resistance on one farm.

Dry-land pasture grass investigations regarding stock-carrying capacity on normal, red maize soil and tests of pure stands of grasses in small paddocks are continued (see Arnold, *Herb. Abstr.* 6. 265. 1936). Yields in ox-grazing days of specific grasses obtained during the six seasons from 1931-7 are tabulated. *Digitaria Pentzii* and Hunyani grass have latterly shown some reduction in productive capacity compared with the early years, but still maintain a carrying capacity greater than that of unimproved veld. Several new varieties of *Digitaria* have been introduced, by courtesy of the Division of Plant Industry, Union of South Africa, and trials to determine the relative value of *Chloris gayana*, Kafue Rhodes and Hunyani grass have been initiated. (See also Arnold, *Herb. Abstr.* 6. 439. 1936.) The feeding value of popular fodder such as maize and Wintersome (a *Sorghum* var.) is below the standard required for high yielding farm animals, and investigations on protein yields of leguminous crops are in progress. *Mucuna* supplies a larger amount of protein per acre than either *Glycine* or *Crotalaria juncea*. A new maize variety, Southern cross, has produced higher yields than the standard varieties during two seasons. Strain trials are also in progress with *Glycine* and *Mucuna*. The latter crop is required for curing as hay in the dry autumn.

From the Plant Breeding Station, Hillside, reports on research in regard to breeding resistant varieties of crops, control of *Striga lutea* and the manurial value of trap crops are included.

Nyasaland Protectorate, Department of Agriculture, 1937.

The Native Welfare Committee appointed during the year an Agronomic Sub-Committee with terms of reference which include among others :—

(1) the setting out of principles for the better utilization of the true agricultural lands, and for the economic utilization of the poorer classes of land in relation to agriculture, the grazing of stock and forestry;
(2) determining measures for soil conservation, with special regard to hill slopes and the erection of wind breaks;
(3) furthering the policy advocated by the Government of early controlled burning of grasses and ground vegetation; and
(4) alleviating evils brought about by overstocking.

At the Zomba Experimental Station good pasture grasses such as *Pennisetum maximum* are increasing on the mountain slopes where rotational grazing is practised. Grasses on the Station plots are fully established and have made good progress with the exception of *Pennisetum clandestinum*, for which conditions appear to be too dry.

Paspalum urvellei and *P. dilatatum* are the foremost species in palatability trials and are followed by Rhodes grass and Woolly Finger grass. The established plots are all pure stands, but further experiments are to include tests on mixed pastures with a legume.

Plant importations recorded include: *Spartina Townsendii* from Essex (seed failed to germinate) and pasture grasses from Kenya (species of *Amphilophis*, *Panicum*, *Cenchrus* and *Cynodon* to be multiplied as quickly as possible).

At the Makwapala Sub-Station where there is a special soil type, the restoration of fertility by rotations is to be studied.

Mauritius, Department of Agriculture, 1937.

It is recorded from the Division of Plant Pathology that the host range of *Bacterium vasculorum* includes *Coix lachryma-jobi* and *Panicum maximum*.

At Rodrigues the improvement of pastures is being studied. Progress has been made with anti-erosion measures and with the establishment of grass species. Activities have been initiated in regard to the placing of an increased acreage under good pasture species and investigating the possibilities of fodder conservation.

INDIA

Imperial Council of Agricultural Research. Agriculture and Animal Husbandry in India. 1937.

The report contains an account of research on fodder crops and grasses carried out at the following centres: 1. The **Imperial Agricultural Research Institute**, formerly at Pusa. See separate report. 2. **Punjab.** Varietal trials are made at the Botanical Sub-station, Sirsa, and include the crops *Andropogon sorghum* (types have been obtained which are an improvement on the local juars), *Sorghum halepense* var. *Sudanensis*, *Vigna catjang* (a mixed crop of maize and cowpeas was found to be best for early sowings), *Euchlaena mexicana* (an exotic crop well adapted to the Punjab climate; it gives a heavy yield of fodder in November when grown either alone or in mixture with *Stizolobium deeringianum*), *Phaseolus aconitifolius*, *Helianthus annuus* (available as green fodder at all times of the year if monthly sowings are made, but the fodder is of low palatability owing to the stiff hairs on vegetative parts), *Panicum maximum* (studied for variation in yield, chemical composition and root development under different cutting systems; highest yield was obtained with two-monthly cuttings, while best root development was obtained with three-monthly cuts), *Chloris gayana* (eight cuttings were obtained during the year with a total of 460 maunds green grass), *Trifolium alexandrinum* (when following *T. resupinatum*, berseem does not require inoculation), *Avena* (early and late-maturing tests), *Melilotus parviflora* (an improved strain, Fo Sl proved superior to the local type), and *Pueraria thunbergiana* (tested as a soil binder in the Kangra hills and appears promising for fodder). 3. **Bombay.** A rotational grazing experiment at Mangadara Kuran has been continued. Increase in live-weight corresponds to freshness of the vegetation and there is indication in marked areas of *Andropogon contortus* that this grass is being ousted by good perennial grasses. Extensions of rotational grazing experiments are noted for various centres, and comparisons of indigenous with imported grasses are made. Trials with *Eleusine coracana* as a fodder crop have shown that cattle thrive on it. 4. **Sind.** One of the most important problems under investigation by the Agricultural Department is the determination of suitable fodder crops for the Barrage areas. Suitable monsoon crops are *Andropogon sorghum*, *Vigna catjang*, *Phaseolus mungo* and *Cyamopsis psoralioides*. *Trifolium alexandrinum*

is a high-yielding winter fodder crop and gives useful results in crop rotations for alkali land reclamation. The high price of imported seed restricts its cultivation. Research on its irrigational requirements both for fodder and seed production are in progress at Sakrand. Important non-leguminous fodders tested are *Avena* sp., *Hordeum vulgare* and *Secale cereale*. The need is for green fodders during April-June and it is proposed to test some perennial fodder crops on low-quality land. 5. **Madras.** Fodders are cultivated at different agricultural stations in the Presidency and study is made of yields. At the Central Farm, Coimbatore, *Pennisetum typhoideum* gave the heaviest yield (167,850 lb. per acre), and was followed by *Panicum maximum* (48,000 lb. per acre). There has been an increase in the area under fodder crops which include *Andropogon sorghum*, *Crotalaria juncea*, *Phaseolus trilobus*, *Pennisetum cenchroides*, *Medicago*, maize, *Euchlaena* sp., and *Helianthus*. Three species of saltbush have been tried at Ootacamund, but only *Atriplex semibaccata* appeared satisfactory. *Pennisetum clandestinum* has given promising results. 6. **Bengal.** Statistical work on the green matter of *Vigna* sp. has proved the superiority of certain types. *Pennisetum typhoideum* has become established as a fodder crop in Bengal. Among pasture grasses, *Andropogon pertusus* and *A. annulatus* are of superior value and the evergreen character of *Panicum abyssinicum* in the driest season is confirmed. 7. **United Provinces.** *Trifolium alexandrinum*, *T. resupinatum*, *Medicago*, *Avena*, and *Pisum* spp. are grown at the various farms of the United Provinces Department of Agriculture. The produce from these and monsoon crops is fed as green fodder, hay or silage. The supply of green fodder throughout the year is being studied at the Imperial Veterinary Research Institute, Mukteswar. One of the promising fodders is an indigenous grass, *Pennisetum flaccidum*. 8. **Bihar and Orissa.** Production of fodder crops is being studied in the area. *Pennisetum typhoideum* supplies food over the greater part of the year, while *Trifolium alexandrinum* and *Medicago* are valuable crops for the cold weather. Analysis of indigenous fodders is to be initiated. 9. **Central Provinces.** The botanical composition of the herbage of Telankheri and Richai farms has been determined. The effect of fertilizers on growth and selection of grasses for seed production are other aspects of the work in progress. 10. **Assam.** Winter crops and grasses are cultivated at the departmental farms. At the Sylhet Cattle Breeding Farm trials of root crops are in progress. *Oryza* sp. and wild aquatic rice is made into silage in the Lower Assam valley. 11. **Indore.** Studies on the improvement of grassland and of *Medicago* are in progress together with root crop trials.

Physiological research on the effect of ions on plant growth has shown that salts of uranium, thorium, cerium, manganese and zinc generally accelerated growth in culture solutions as measured by increase in height and total dry matter of the plants. Seeds soaked in dilute solutions of the salts germinate more quickly and there is improvement in the early stages of plant growth. The culture results have been confirmed in plot experiments.

The section on animal nutrition records work on a survey of grasses in the North Malabar district, where pastures show marked deficiencies in calcium and phosphorus. Analysis and feeding experiments have been made with *Eichhornia crassipes* and *Pennisetum typhoideum* at Rangpur. Other feeding trials made in the Punjab (on silage) and in Bihar are noted.

Bengal, Department of Agriculture, 1937-8.

The Second Economic Botanist records that selection work with *Vigna* sp., *Andropogon sorghum*, *Zea mays*, and other pasture grasses is continued. *Pennisetum typhoideum* has already established itself in the various districts of Bengal as a heavy-yielding fodder crop.

The Section of Animal Nutrition under the Agricultural Chemist includes studies on the feeding value of autumn rice straw (*Herb. Abstr.* 8. Abs. 1743) and of *Eichhornia crassipes* (*Herb. Abstr.* 9. Abs. 627).

Manurial trials with *Pennisetum typhoideum* at the Dacca Farm are reported and tabulations are available of yields under seven different treatments at varying harvest dates. Chemical fertilizers produce greater yields than organic manures and, apart from the control, yields from plots treated with lime are greater than those from plots not so treated. An area of 61.98 acres has been grown under green fodder to meet requirements of the dairy and farm herds. The crops include *Pennisetum typhoideum* 40.41 acres, *Zea mays* 16.54 acres, *Andropogon sorghum* and other grasses 5.03 acres. Juar and maize grew well but *P. typhoideum* over a period of five years fell off in condition and gave a low return.

Bihar, Agricultural Department, 1937-8.

There is evidence of mineral deficiency in fodders grown in certain areas in Bihar, and a scheme has been started in which indigenous fodders are analysed. The studies include (1) analyses for specified mineral, fibre and volatile organic constituents ; (2) effect of age on mineral content (analyses to be made at pre-flowering milk-ripe and mature stages) ; (3) relation of chemical composition of fodders to that of the soil in which they grow ; (4) seasonal variation in composition of the fodders ; and (5) effect on composition of cultivation and manuring. The fodders tested are maize, *Andropogon sorghum*, *Phaseolus* spp., *Glycine*, oats, *Carthamus tinctorius*, *Euchlaena*, *Pisum*, *Lathyrus sativa*, *Vigna* sp., *Cyamopsis* sp., *Dolichos biflorus*, *Trifolium alexandrinum*, *Medicago*, *Pennisetum* sp., *Panicum maximum*, *Cynodon dactylon*, rice straw, and sugarcane leaves, etc. Notable results obtained during 1937-8 are (a) that *Pennisetum* sp. shows a very high content of protein, phosphoric acid and lime, and in this respect appears to be a much better fodder than maize or *Andropogon sorghum* ; and (b) although fodders grown at the Kanke and Sabour farms differ widely in their mineral content, no actual relationship can be established between the available nutrients in the soils of these farms and the mineral content of the fodders grown on them.

In the Botanical Section varietal trials are in progress with various plants which include maize and several legumes.

Mukteswar and Izatnagar, Imperial Veterinary Research Institute, 1936-37.

A review of the grazing problem in India has been made during the course of the year (Ware, *Agric. Live-Stk. India*, 7. 141. 1937.) The annual yield of fodder hay together with improvement work on the farm cultivation area, which includes eradication of rough grasses and sowing winter and monsoon crops, are recorded.

The analysis of various indigenous and cultivated pasture grasses found in different parts of the country as well as the determination of their nutritive values for purposes of maintenance, growth, work, milk, wool and other forms of production, have been carried out. The variations in the organic and mineral composition of the herbage as influenced by conditions of soil, season, climate, species and stage of maturity at the time of harvest, are also studied. The effects of the above factors in determining the nutritive value of the material and their physiological effects on animal metabolism have been found to be of great importance. Physiological studies include mineral feeding experiments with different fodders in which deficiencies of lime and phosphorus were noticed.

With advancing maturity of the herbage there is, up to the full bloom stage, a rise and thereafter a steep decline in protein content and feeding value. The varia-

tions in mineral composition of these feeds is found to be reflected in blood composition when they are fed to animals. Composition also varies with species. Even when the same species was grown at different places in the same year, or in the same place during different years, wide fluctuations in composition were noticed. In the course of a study of the sulphur partition of Indian grasses (Warth and Krishman, *Indian J. Vet. Sci.* 7. 54. 1937) it was noticed that, among grasses growing side by side, species of the Chloridae contained more sulphate than others and the stalks had a higher sulphate concentration than the leaves in the same plant. The latter fact was found to be reversed in the case of lucerne.

The present position of the knowledge of the vitamin A requirements of farm animals in relation to vitamin A content in common roughages has been considered (Sen and Seshan, *Indian J. Vet. Sci.* 8. 169. 1938).

Agra and Oudh, United Provinces of, Cattle Census Report for 1935.

Owing to climatic conditions true pasturage is not to be had all the year round in most villages of the plains. There are 369 acres of grazing land per thousand of bovine population in the province as a whole, while the average grazing area per thousand of total animal population is only 277 acres. There is, therefore, roughly one quarter of an acre of grazing land per animal in the province. The need for suitable management of available grazing areas and the production of fodder crops is noted. In the province as a whole only 3.6 per cent of the cultivated area is under fodder crops, giving an average of 29 acres per 1,000 animals.

Indore, Institute of Plant Industry, 1937.

The Institute of Plant Industry is a Society, one of the primary objects of which is to develop agriculture in those Indian States which are members. Owing to the fundamental importance of bullock-power to local agriculture attention is given to the problem of adequate feeding of work-cattle. Preliminary surveys have been made in 1932 and 1934 in Malwa to estimate yield of edible grasses and weeds from natural grasslands and grass borders of cultivated fields. There is need for increasing yield from the poorer types of grassland which predominate, and the maintenance of suitable grass borders for cultivated fields should be examined from the point of crop economy. The study of the effect of contour strips of suitable vegetation to control erosion in areas excluded from crops is to be continued.

Medicago is grown to a limited extent in Malwa but the stand becomes scanty, weedy and unprofitable. Study of measures necessary for improvement was initiated in 1932. Results obtained show that yields were increased chiefly from increased phosphate supply while doses of organic matter had no appreciable effect. Methods of cultivation did not affect yields and increases due to inoculation were slight. Experiments with other crops had shown that soil deterioration might be reduced by the Indore method of treatment. This was, therefore, tested and results for the first year show that supplementary doses of superphosphate are unnecessary for lucerne on poor land.

In Rajputana carrots are grown for fodder wherever possible. Sugar-beet grew satisfactorily during 1934 in the Jaipur State, the maximum yield of roots being obtained from the harvest in May. A replicated experiment was carried out in 1935 at different centres (Jodhpur, Jaipur, Alwar and Bundi) to compare sugar-beet yields with those of carrots when both were harvested at the time usual for carrots. Root crops (carrots, sugar-beet and varieties of mangolds) have also been compared regarding feeding value.

Trials started in 1932 have shown that soybeans can be grown in the Central

India Agency tracts. Information on yields and chemical composition is available for different varieties. The effect on wheat of green manuring (notably *Crotalaria juncea* and *Vigna* sp.) is included in the experiments. The section on soil erosion gives a classification of crops (mostly with good feeding value) of use for erosion control, their habit and mode of regeneration. Comparisons are also made of five crop rotations, of the influence of previous crops on yield of succeeding ones, and of the influence of biological eradication of weeds on subsequent crops and soil.

Selection and breeding work is in progress with specific monsoon and winter crops.

Central Provinces and Berar, Department of Agriculture, 1937.

Reports of the Departments for 1936 and 1937 include an account by the Agricultural Chemist, Central Provinces. Work completed has been published by Bal and Athawale, *Herb. Abstr.* 7. 33. 1937.

Research described in the report of the Second Economic Botanist includes strain trials with *Cicer arietinum*, *Cajanus indicus*, mung (*Phaseolus radiatus*), urid (*Phaseolus mungo*), and *Glycine*. The botanical composition of the herbage at Telankheri and Richai farms has been determined, and the effect of different fertilizers on growth is being investigated in collaboration with the Agricultural Chemist. Selected varieties of grasses are grown for seed production.

The account by the Economic Botanist of work in connexion with cotton and its rotation crops includes description of selection and hybridization with *Arachis* sp., *Andropogon sorghum* and *Pennisetum typhoideum*.

Punjab, Department of Agriculture, 1937.

Varietal trials are in progress with *Sorghum* sp., *Andropogon sorghum* var. *Sudanensis*, *Vigna* sp., *Euchlaena mexicana* (successfully introduced into the Punjab), meth (*Phaseolus aconitifolius*), *Helianthus*, Guinea and Rhodes grass, oats and *Trifolium alexandrinum*.

Owing to conditions of drought and inadequate supplies of irrigation water during the 1935-6 season, seed production was interfered with, particularly in late varieties. It is suggested that the headquarters of the Fodder Specialist be removed from Sirsa to Sargodha.

Studies are in progress, in collaboration with the Agricultural Chemist, on other fodders which include Guara (*Cyamopsis psoralioides*); Metha (*Trigonella foenum-graecum*), Senji (*Melilotus parviflora*), Japan rape (*Brassica campestris* var. *rapa*), *Medicago*, *Pueraria thunbergiana*, and pasture grasses such as anjan (? *Pennisetum cenchroides* or *Cenchrus biflorus*), Palwan (*Trichosanthes dioica*) and doob (*Cynodon*.)

In the Animal Nutrition Division feeding trials on *Pennisetum cenchroides* cut at early growth stage and when fully ripe, form the basis of work in connexion with the farming economy of grass systematically grown for fodder.

New Delhi Imperial Agricultural Research Institute, 1937.

The Institute was transferred from Pusa to New Delhi following the destruction of the former Institute in the Bihar earthquake in 1934. The work of three decades at Pusa is reviewed in the report of the Institute on pages 15—90. The Sections include :

Fodder and forage crops. Imported fodder grasses flourish during the monsoon period when there are other grasses in abundance, but they are of no value in hot weather or winter when other feed is not available. *Trifolium alexandrinum* is the

best irrigated winter fodder crop for the milch herd and *Cyamopsis psoralioides*, *Vigna* spp., *Phascolus aconitifolius* and *Glycine* are the best hot weather fodders.

Rotations. Maize is grown for fodder in the monsoon season, and *Cajanus cajan*, oats and gram in the winter. Research by Joshi and Vyas has indicated that the maize plant is in some way connected with nitrogen fixation.

Data are also available on varietal trials, soil studies and water requirements of crops, nitrogen fixation, fertilizers and plant nutrition. In the last section studies by B. Viswa Nath have clearly indicated the distinction between plant growth and development. The growth phase predominates in the early part of a plant's life and is marked by intense activity in building up complex substances (carbohydrates, proteins), while during the developmental phase the processes of hydrolysis, re-synthesis and elaboration predominate. Inherent differences due to variety affect the length of the first phase and factors operating in this phase may influence the second.

The report by the Imperial Agriculturist includes (a) a programme of the work for 1937-8 in which is incorporated the growing of fodder crops for cattle and a study of rotations for building up the fertility of the New Delhi Farm ; (b) work in progress at the Agricultural Substation, Karnal, where plant culture and yield trials are made ; and (c) research of the Statistical Branch.

The report of the Imperial Economic Botanist describes investigations on (1) breeding wheat, *Cajanus* and other crops for disease resistance, (2) inheritance studies, (3) investigation of hybrid vigour and correlation studies, and (4) varietal trials in wheat, paddy, peas and sunn hemp.

The Imperial Agricultural Chemist reports on varietal differences in plant nutrition. The absorption of nutrient elements by nine different families of plants growing under natural conditions is studied by A. T. Sanyal. Evidence is obtained that Gramineae contain less lime than Cucurbitaceae, while the Leguminosae occupy an intermediate position. Also plants in the Gramineae family yield ash free from carbonate, while others are characterized by ash containing varying amounts of carbonates. The programme outlined for 1937-8 includes research on nitrification and its significance in plant nutrition, N fixation in soils and crops and effect of soil conditions and plant nutrition on crop quality.

Study of diseases of cereals and legumes (*Cicer*, *Dolichos*, *Crotalaria* and *Cajanus*) is reported by the Imperial Mycologist.

The Imperial Entomologist's report includes an account of the stem borers of sugarcane at Pusa ; *Diatraea* spp. were found to be more injurious in reducing the weight and sucrose content of cane than either the top shoot or the root borers. In India *Agromyza obtusa* and *Dasyneura lini* are important pests of *Cajanus cajan* and linseed respectively, both of which were fully studied.

Bombay Presidency, Department of Agriculture, 1935-36.

Research in the Crop Physiology Section on bioclimatics has shown that factors such as rate of germination and fluctuation in the sub-soil water table exert an influence on crop growth and mask the effect of climate to some extent. Investigations on soil moisture movement in relation to water requirements of crops, on irrigation and manurial practices are in progress.

The water requirement of three strains of *Sorghum* spp. has been determined. It is shown that addition of farmyard manure increases the efficiency of the plant's water utilization and that the presence of a larger quantity of water decreases this efficiency and gives a high transpiration coefficient. The strains have been analysed at four stages of development and mineral food requirements have been studied.

In the North Central Division in the Khandesh and Nasik districts, *Medicago* is increasing in popularity as a fodder crop. At East Khandesh, West Khandesh and Nasik respectively, 1,248 lb., 4,348 lb., and 500 lb. of seed have been distributed.

One of the greatest achievements of the Agricultural Department appreciated in the Southern Division is the eradication of prickly pear (*Opuntia monocantha*) by introduction of the cochineal insect (*Dactylopius coccus*).

Work done under the direction of the Professor of Agriculture, Poona, includes study of the effect of leguminous crops in rotation with a cereal on yield of cereal, and varietal trials with *Glycine* and with *Lespedeza*.

The report of the Economic Botanist to the Government of Bombay records experiments in (1) rotational grazing and effect of grazing alone on live-weight of animals; (2) ousting of *Andropogon contortus* by perennial grasses; (3) shrub clearing; (4) a grazing test at the Gilligan Cattle Breeding Farm, near Jalgaon, East Khandesh; (5) a survey of grass vegetation at the Chinchola Kuran has been made with a view to initiating rotational grazing experiments, at the request of the Deputy Director of Agriculture, North Central Division, Nasik; (6) factors influencing germination of *Striga* seeds have been studied and *Striga*-resistant *Sorghum* varieties are being selected; (7) acclimatization of Australian grasses (six species germinated well and are to be grown on a larger scale: genera not given); (8) classification of *Cajanus indicus* and *Vigna* sp.; (9) vernalization tests with bajri (*Pennisetum typhoideum*), *Vigna* sp., *Sorghum* and *Triticum* have been made to check results previously obtained, to observe whether there are cumulative and residual effects on progeny of plants treated in the previous year, and to devise new methods of vernalizing; (10) East African *Sorghum* varietal trials have shown that none of the thirty-three promising types is suitable for grain but most are good fodder-producing types.

Breeding and selection work with *Pennisetum typhoideum*, *Dolichos lablab* and *Cicer arietinum* is in progress under the direction of the Crop Botanist to the Government of Bombay, Karkjat.

The Plant Pathologist reports that *Oidiopsis taurica* is recorded on *Cajanus indicus* apparently for the first time. Tests on the pathogenicity of certain fungi which produce wilt in *Lathyrus sativus*, an important cold season crop in the Broach district, are being made.

At the Cattle Breeding Farm, Bankapur, experiments with various types of indigenous and imported grasses are made, together with study of *Eleusine* as a fodder crop, and of *Glycine* yields.

Madras Presidency, Department of Agriculture, 1936-7.

Research projects include the following: (1) Effect of a mixture of sorghum and pulse on succeeding cotton. Best results are obtained with three parts of the cereal to one of pulse. It has been noted that the growing of certain legumes in association with sorghum was not beneficial to the succeeding cotton. (2) The Madras Fodder Cholam Scheme. This has been in progress for a full period of six years and has included experiments on spacing, manuring, growing *Sorghum vulgare* mixed with pulses, and on sowing times and rates. Sodium ions in the soil increase as a result of growing cholam. (3) The cultivation of fodder crops at different agricultural stations in the Presidency. At the Central Farm, Coimbatore, elephant grass yielded nearly 167,850 lb. green mass per acre. The average acre yields of Periamanjal cholam, maize and Guinea grass were 18,600, 16,360, and 48,000 lb. respectively. At Palur, where four acres were put under fodder, teosinte and fodder cholam yielded 34,840 and 24,600 lb. green mass per acre respectively. (4) Varietal trials are in progress with *Glycine*, *Cajanus indicus*, *Cicer arietinum*, *Vigna* and *Dolichos*, together

with certain cereals for fodder. Plant selections have been made to obtain sorghum varieties resistant to *Striga*. A particular variety notable for its resistance in the Kurnool and Guntur districts is susceptible in Coimbatore.

A comparative test, made at Coimbatore, between fodder sorghum and fodder maize showed that the tonnage of sorghum sown between August and January was poor compared with that sown during the remaining months of the year, whereas maize behaved fairly uniformly throughout the year. It is considered advisable to grow maize between September and January and to confine the growing of sorghum to the remaining seven months of the year. Sweet potato vine when given as green fodder for milch cattle resulted in a marked increase in milk yield. Other fodder crops tested regarding yield, palatability, etc., include *Phaseolus trilobus*, various sorghum strains and *Atriplex nummularia*.

In the Chemical section of the Research Institute a number of grasses have been analysed for mineral content. Those from the hill grazings near Coimbatore showed serious deficiencies in minerals, while pastures in Ongole Taluk of the Guntur district showed that they had a good mineral content. The need for systematic research of pastures in different cattle breeding districts is stressed.

In the micro-biological experiments an organism has been isolated and investigated for its nitrogen-fixing power. A method has been developed to inoculate cereal seeds such as sorghum and wheat with a culture of the organism and results are promising.

Madras, Department of Agriculture, 1936-7.

Administration report of the Deputy Director of Agriculture.

I Circle, Vizagapatam.

The drought of the year 1935/6 gave an impetus to the increase of the area in the district under fodder crops such as *Sorghum vulgare*, sunn hemp and *Phaseolus trilobus*. In the Rajahmundry division the introduction of *P. trilobus* in the delta has helped towards solving the fodder problem and the area under this crop has considerably increased during the year, and now occupies about 16,000 acres. Sunn hemp as a 'pyru' (late season—Dec. to February) crop after rice is generally grown for fodder.

Varietal trials at the Samalkot Agricultural Research Station are in progress with *Phaseolus mungo* and *Glycine*.

II Circle, Guntur.

Jonna (*Andropogon sorghum*) is generally sown for fodder in the Kistna and Guntur districts and improvements which have been in progress include (a) the introduction of *Phaseolus trilobus* as fodder or in mixture with jonna, where this is not the practice; (b) introduction of *Euchlaena* sp. in rich soils; (c) introduction of *Pennisetum cenchroides* in pasture lands; (d) *Ipomoea hispida* as fodder for milch cattle in special localities; (e) Guinea grass under irrigated conditions; (f) maize and jonna fodder for conversion into silage in special localities; (g) conversion of grass into hay under shade; (h) introduction of sweet varieties of jonna for fodder, for example, T-6, T-12 and T-1.

III Circle, Bellary.

There is an increase in the areas sown to improved strains of *Arachis hypogaea*, Italian millet and *Eleusine coracana*. In this region there is a wide range of soils and differences in rainfall, and particular importance is attached to comparing strains of crops and to new cultural practice over an extensive area. A large number of trial plots has been laid down on ryots' land and the work is in charge of senior officers at

Hagari and Nandyal. The crops include *Sorghum vulgare*, *Setaria italica* and *Eleusine coracana*. At the Dry Farming Research Station, Hagari, work is in progress regarding seed improvement of Italian millet, *Eleusine coracana* and *Cicer arietinum*. Physiological and ecological studies include investigations on root systems and moisture necessary for optimum germination.

Varietal trials made at these centres include work with *Arachis*, *Glycine* and *Phaseolus trilobus*. Newly introduced crops are *Glycine* and *Atriplex nummularia*. The saltbush grows well under light irrigation, but cattle so far have avoided it.

An experiment to compare the yield of cotton and *Sorghum vulgare* in a two-year rotation with a three-year rotation including ground nut has been continued. A great increase in cholam yield results from growing groundnut once in three years.

IV Circle. St. Thomas Mount.

The records include data on seed production and distribution of varieties tested. Maize, teosinte, cholam, Guinea grass, elephant grass and lucerne have been introduced into several areas.

V Circle. Trichinopoly.

The growing of *Sorghum vulgare*, *Pennisetum cenchroides*, Guinea and elephant grasses is encouraged in the two districts (Trichinopoly and Tanjore) of the circle. Data on seed production and distribution during the year are supplied. The growing of green manure crops is important and production of seed for green manure is increasing, the area under such crops being 63,086 acres.

At the VI Circle, Madura, the VII Circle, Tellicherry, and the VIII Circle, Coimbatore, similar trials are in progress. In the last region *Medicago* has proved satisfactory and there is increased demand for seed; during 1936-7, 74 lb. were supplied and the crop is estimated to occupy 107 acres in small plots in different parts of the circle.

The Administration Reports of the Government Agricultural Chemist record that, as shown from analyses, grasses from hill grazings near Coimbatore had serious deficiencies in minerals, while those from the Ongole taluk of Guntur had a very good mineral content.

The Administration Reports of the Millets Specialist includes accounts of work in progress with (1) *Sorghum vulgare* (varieties are studied in regard to their suitability for fodder purposes, and for resistance to attack by *Striga*), (2) *Vigna catjang*, *Eleusine coracana*, *Panicum miliaceum*, *Dolichos lablab*, *Prosopis juliflora* (a tree yielding pods edible by cattle and sheep) and *Glycine hispida*.

The Administration Reports of the Government Entomologist and of the Government Mycologist describe pests of *Sorghum vulgare* (*Calocoris* sp.) and *Sesbania aculeata* (*Semiothisa* sp.), fungous diseases of cereals (*Sclerospora* sp.) and virus diseases of *Cajanus indicus* and *Sorghum* sp.

Burma, Department of Agriculture, 1938.

The Economic Botanist reports on selection work with *Cajanus cajan*. In all, 114 strains which gave high yield and were resistant to insect attack have been grown at Mahlaing and further selections have been made. Strain trials are also made with varieties of *Glycine*, *Phaseolus* spp. and *Cicer arietinum*.

At the Agricultural College Farm, Mandalay, the problem of maintaining a supply of succulent fodder all the year round is studied. *Pennisetum Merkeri* and *Panicum maximum* are grown under irrigation. A small area of *Medicago* has produced succulent feed during the dry season. From 0.15 acre, three cuttings (at intervals of two to three weeks) have yielded 695 lb., 530 lb. and 420 lb. Excessive use of green lucerne is not recommended near milking time because of feed flavour. It has been found possible to reduce the amount of concentrates by feeding a mixture of straw chaff and pechinbaung (*Lathyrus sativus*).

Dry crops sown for seed and/or fodder include saccoline (a fodder millet), gram (*Cicer arietinum*), kunpyaung (*Sorghum vulgare*), pesinngon (*Cajanus* sp.), *Triticum*, *Medicago*, *Pennisetum Merkeri*, *Panicum maximum* and *P. muticum*. Tabulations of area sown and yields are supplied.

Ceylon, Department of Agriculture, 1937-8.

The following are among the records of the Entomological Division : damage to young areas of kurakkan (*Eleusine coracana*) by various species of locust : the stem-boring caterpillar (*Azygophleps scalaris*) on *Sesbania speciosa* ; *Prodenia* sp. and *Heliothis* on *Crotalaria juncea* ; *Brachyacma* sp. and *Araecerus fasciculatus* in pods of *Tephrosia* spp. ; and stem-boring grubs of *Colobodes billbergi* in *Cajanus cajan*.

Diseases of plants in Ceylon (recorded in 1937 for the first time by the Plant Pathology Division) are produced by : *Rhizoctonia solani* on *Cicer arietinum* ; species of *Ceratophorum*, *Poria* and *Sclerotium* on *Crotalaria anagyroides* ; *Rhizoctonia solani* on *Glycine max* and *Phaseolus aureus* ; *Sclerotium rolfsii* on *Tephrosia candida* and species of *Corticium*, *Fomes* and *Polyporus* on *Tephrosia vogelii*.

Minor investigations of the Division have included a test on the efficiency of three strains of the *Glycine* nodule bacterium obtained from Java and one strain from England in a sand-culture pot experiment. Using dry weight of the plants as a basis for calculation, plants inoculated with any of the strains were significantly superior to the control plants. Further experiments have shown that seed inoculation induced greater growth as measured by plant height.

The work of the Chemical Division includes fodder grass manurial trials. It has been established that the optimum time for cutting *Pennisetum typhoideum* at Peradeniya is once in six weeks.

The Division of Botany is concerned with selection of *Eleusine coracana*, *Glycine max*, and *Vigna unguiculata*.

The report from the School Farm and Experiment Station, Peradeniya, records trials with pasture and fodder grasses. *Pennisetum clandestinum* and *Cenchrus ciliaris* are suitable for Peradeniya conditions. It has been determined that the best height of cutting *Pennisetum typhoideum* is 2 to 3 inches in contrast to 7 or 8 inches, because the lower height encouraged more tillering. Calculated yields of a 12-months varietal trial in the best periods of growth gave the following results : 85.5 tons for *P. typhoideum*, 70.2 tons for *P. Merkeri*, 63.7 tons for *Panicum maximum* and 36.4 tons for Guatemala grass (? *Tripsacum* sp.)

The Soil Conservation Division is studying vegetative cover and crop rotations in relation to soil conservation.

CONFERENCES

Association of Scandinavian Agricultural Research Workers

The Finnish Section of the above held its annual meeting in Helsingfors on May 4, 1939.

An address was delivered by Dr. C. A. G. Charpentier, Director of the State Grassland Experiment Station at Selkee, dealing with the results obtained during the first five-year period.

Results obtained hitherto from experiments with seeds mixtures on pastures appear to indicate that simple seeds mixtures, at least during the first years, give as good a yield as so-called complete seeds mixtures. This could be expected as long as the red clover maintained itself in the ley. The experimental results in the following years will show whether the leys sown with simple mixtures will remain equal to the leys sown with complete seeds mixtures.

In experiments to improve old hay leys given up to pasture, harrowing and subsequent supplementary sowing (31 kg. per ha.) have given the best results, 2,668 food units per hectare.

The results of an experiment to promote the ley's growth of clover show that supplementary sowing without other measures is best. On pastures such a sowing of clover is appropriate, particularly on those areas which are difficult to cultivate.

In the nitrogenous manurial experiment on pasture leys, the manuring has increased the yield year by year. Nitrogenous manuring has increased the yield by approximately 600 food units per hectare. Some shifts were ploughed and sown afresh, and on these nitrogenous manuring during the first experimental year increased the yield by 800 food units per hectare. An important prerequisite for the profitableness of such manuring is the carrying out of a proper sowing of seed in putting down the pasture ley.—R.P.J.

Ecological Society of America

This Society held its annual summer meetings at Stanford, California, on June 26 to July 1, 1939, and at Milwaukee, Wisconsin, on June 20 to 24, 1939. The following papers were among those presented to the Stanford meeting.

Symposium: Recent contributions of botany and ecology to human welfare.

1. Recent achievements in plant breeding. E. B. Babcock.
2. Some recent contributions of animal ecology to human welfare. T. I. Storer.
3. Mycology in the service of mankind. E. P. Meinecke.
4. Some recent contributions of plant ecology to human welfare. H. L. Shantz.

Polygonal graphing of ecological data. A. H. Hutchinson.

An electrical apparatus for accurate ecological measurements. LeMont C. Cole.

Studies of the vitality and crude fat content of the Beet Leafhopper during winter in California. William C. Cook.

The role of bracken fern in Douglas Fir reproduction. W. F. McCullock.

Among the papers read at the Milwaukee meeting were :

Mathematical systematization of " environment ", " organism ", and " habitat ". Edward Haskell.

Prairie restoration on the University of Wisconsin Arboretum. T. M. Sperry.

Geography and land use. K. C. McMurray.

The economist's approach to the problem of ecology. G. S. Wehrwein.

The broader social implications of land use in the Cutover region. Raphael Zon.

South African Association for the Advancement of Science

The above Association held its thirty-seventh annual meeting in East London on July 3 to 8, 1939. Among the papers read at the meeting were :

An ecological study of light and temperature relations in typical *purple veld* of the Highveld of the Transvaal—a critique of methods. Margaret Matheson.

The fertility requirements of Kikuyu. D. Meredith and Z. Deenik.

A further contribution to the ecology of the Highveld grassland at Frankenwald, in relation to grazing. H. J. van Rensburg.

Germination of Karroo Bush seed. Dr. M. Henrici.

The effect of some nodule bacterial strains on the growth and composition of *Trifolium repens*. W. G. Goldschmidt and Dr. E. R. Orchard.

Preliminary studies on the root systems of *Euphorbia mauretanica, E. Burmanni* and *Ruschia multiflora* on the Worcester Veld Reserve. J. D. Scott and N. G. van Breda.

An improved method of sowing Karroo shrub seed. N. G. van Breda.

A preliminary report on methods of thorn-bush eradication. J. D. Scott.

A further comparative study of the osmotic values of the leaf saps of certain South African Highveld grasses. Clara Weinbrenn.

A contribution to our information on veld-burning in South Africa. Lynette Cook.

The text of these articles will be published in due course in the South African Journal of Science, Vol. 36, and will then be abstracted in *Herb. Abstr.*

Anatomical Conference

In view of a contemplated conference, V. G. Aleksandrov, Officer-in-Charge of the Anatomy Division at the USSR Institute of Plant Industry, Leningrad, reported to a meeting held at the House of Scientists, Moscow, on January 27, 1939 (*Bot. Ž.* Vol. 24. p. 182. 1939). In this report the participation of plant anatomy in the elucidation of the following research items was proposed for discussion at a forthcoming conference :

(1) Seed ripening
(2) Seed germination
(3) The quality and quantity of products of plant activity (proteins, starch, caoutchouc, alkaloids, etc.)
(4) Useful structural characters
(5) Physiological resistance (winter hardiness, drought resistance, etc.)
(6) Ecological adaptation, having in view "training of plants"
(7) Phylogenetic relationship between forms and groups of forms for systematic purposes

It was emphasized that anatomical analyses are required not only to supplement investigations of physiologists, biochemists and systematists, but also technological studies of immediate importance to rural husbandry and agricultural industry.—M.A.O.

ANNOTATIONS

Netherlands (492)

State Agricultural Station, Groningen

A summarized report on experiments in the use of nitrogenous fertilizers on the State Mine Experiment Fields, 1931-35, and at Duurswold and Noord-Drente, 1935, is contained in *Versl. Landbouw. Onderzoek.* 44. (18) A. 857-1045. 1938. The report is presented by the Groningen Experiment Station under the names of O. de Vries, W. C. Visser, H. J. Frankena, T. B. van Itallie and D. M. de Vries. The five-year experiments numbered seventy-eight, thirty-seven of which were on grassland ; 245 harvests were concerned, 136 relating to grassland. The trials were located in widely different parts of the Netherlands, were conducted under the supervision of the Government Agricultural Advisors (Rijkslandbouwconsulenten), and were subsidized by the Board of Directors of the State Mines, which was interested in problems affecting the country's requirements in nitrogenous fertilizers. From time to time detailed reports, appearing in limited numbers only, have been published by the Agricultural Advisors, and on the mass of information contained therein the Groningen Station has based the present report, which necessarily deals with the broader aspects of the results obtained. To supplement the work of the State Mine experiments, the Station itself conducted twenty experiments in 1935.

Parts of the report are concerned with the results in their relation to soils, manurial treatment, and yield. There is also a chapter on the chemical analysis of the grass as related to (1) the kind of nitrogenous fertilizer employed, (2) N or no N, (3) botanical composition, (T. B. van Itallie, pp. 939-53) ; and another on the botanical composition of the hay from the State Mine Fields from 1931 to 1935 (D. M. de Vries, pp. 954-73).—G.M.R.

Algeria (65)

Agricultural Laboratory and Plant Breeding Station, Algeria

The report on the Station's work is presented by P. Laumont (1938, pp. 3).

Control of seed imports, herbage and forage plants. Samples analysed number 117, and corresponded to 47,380 kg. of imported seed. This included, in addition to lucerne, various legumes, ryegrass and small grasses, a large proportion of sorghum and berseem (*Trifolium alexandrinum*). No consignment was rejected on account of *Cuscuta* content. An increased importation of *Trifolium pratense* is noted.

Work in connexion with the improvement of forage plants includes the reproduction of two *Medicago* varieties, namely, Turkestan and Arizona, the collection of material in berseem, *Trigonella foenum-graecum*, *Glycine Soja*, *Lespedeza*, *Crotalaria*, *Vigna*, etc., and the initiation of selection in *Vicia sativa* (sixty strains).—G.M.R.

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Copies of publications and/or scientific reports of which the applicant is the author must be attached to all applications where possible.

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Application must be made on prescribed form (Z.83) which is obtainable from the Secretary, Office of the High Commissioner for the Union of South Africa, South Africa House, Trafalgar Square, London, to whom all completed forms must be addressed. Applications must reach the High Commissioner's Office not later than 30th September, 1939.

HERBAGE REVIEWS

A quarterly journal devoted to current grassland, forage crop and plant biological research, issued in conjunction with Herbage Abstracts and Bulletins.

Vol. 6. No. 3. 1938. (pp. 129-219).

Articles:

Ley-farming and a long-term agricultural policy. R. G. Stapledon.
United States Regional Pasture Research Laboratory. R. J. Garber.
Plant regeneration and pasture improvement under arid and semi-arid conditions in South Australia. H. C. Trumble.
The Ontario Agricultural and Experimental Union. G. P. McRostie.
Grassland farming in New Zealand. P. W. Smallfield.
The legumes of grassland. E. Klapp.

Reviews:

Variation within strains in Norwegian red clover.
Some recent advances in agriculture.
Ecology in agriculture.
Taxonomy of Bromus.
Canadian Weed Control Committee.
The vegetation of Petén.

Conferences.

Annotations.

Vol. 6. No. 4. 1938. (pp. 221-296).

Articles:

Illustrated notes on the technique of grass-breeding at Aberystwyth. A. R. Beddows and A. G. Davis.
Seed production of the *Poa* species. E. Åkerberg.
Reflections concerning new crop varieties. J. W. Gregor.
Grassland panorama of the La Plata region. A. Boerger.
The German soybean problem. W. Riede.

Reviews:

Spartina in the Netherlands.
Herbage plant improvement in Finland.
Research at a Soil Conservation Experiment Station.
Pasture improvement in Eastern Canada.
Ecological survey of the mountain area of Basutoland.

Conferences.

Annotations.

Vol. 7. No. 1. 1939. (pp. 1—57).

Articles:

The organization of herbage and forage crop production in Germany since 1933. R. Geith.
The trend towards a grassland agriculture in the United States. P. V. Cardon.

Reviews:

Production of forage in Southern Italy.
The comparative nutritive value and relative cost of forage (pasture and hay) and other crops.
Phasic development of plants. (1).
A revision of the theory of vernalization.
Manual of plant breeding.

Conferences.

Annotations.

Seed Exchange.

Vol. 7. No. 2. 1939. (pp. 59—150).

Articles:

Anatolian lucerne. F. Christiansen-Weniger and O. Tarman.
The fundamental factors of the Uruguayan forage problem. A. Boerger.

Reviews:

Pasture research and erosion control in South Africa.
Plant communities of Western Queensland.
Survey of the tussock-grasslands of the South Island, New Zealand.
Clover and malaria.
Phasic development of plants (2).
The temporary ley.
Erosion and other surveys in East Africa.

Scandinavian Literature:

Measures calculated to ensure a satisfactory pasture yield under severe climatic conditions.
Rational production of seed of meadow plants.
Holt, the most northerly Agricultural Experiment Station in the world.

Annual Reports.

Conferences.

Annotations.

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